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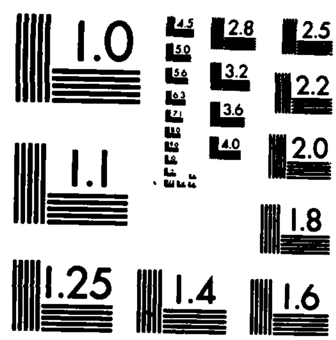

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INSTRUCTION REPORT K-83-3

USER'S GUIDE: COMPUTER PROGRAM FOR SOIL-STRUCTURE INTERACTION ANALYSIS OF SHEET PILE RETAINING WALLS (CSHTSSI)

by

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Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a computer program--CSHTSSI--for soil-structure interaction analysis of sheet pile retaining walls. The model employed for analysis of the wall-soil system is a special case of a general beam-column. Hence, CSHTSSI is a special-purpose application of the general-purpose, beam-column analysis program CBEAMC. The report:

a. Describes the wall-soil system.

(Continued)

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20. ABSTRACT (Continued)

b. Presents the procedures employed to generate nonlinear pressure-displacement curves from soils data.

c. Outlines the method of solution.

d. Provides example solutions obtained with the program.

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PROGRAM INFORMATION

Description of Program

CSHTSSI, called XØØ7Ø in the Conversationally Oriented Real-Time Program-Generating System (CORPS) Library, is a computer program for the soil-structure interaction analysis of sheet pile retaining walls. The model employed for the analysis of the wall-soil system is a special case of a general beam-column with the soil modeled by linear and/or nonlinear springs. It is intended to be an easy-to-use program incorporating the capabilities required by a diverse group of users. CSHTSSI utilizes the finite element method of structural analysis to model the beam column.

Coding and Data Format

CSHTSSI is written in FORTRAN and is operational on the following systems:

a. WES Honeywell DPS/1.

b. Harris 500 computers which are located at most district Corps offices.

c. Control Data Corporation, Cybernet Computer Service's CDC CYBER systems.

Data can be input either interactively at execute time or from a prepared data file with line numbers. Output may be directed to an output file or come directly back to the terminal.

How to Use CSHTSSI

A short description of how to access the program on each of the three systems is provided below. It is assumed that the user knows how to sign on the appropriate system before trying to use CSHTSSI. In the example initiation of execution commands below, all user responses are underlined, and each should be followed by a carriage return.

WES Honeywell System

After the user has signed on the system, the two system commands FORT and NEW get the user to the level to execute the program. Next, the user issues the run command.

RUN WESLIB/CORPS/XØØ7Ø,R

to initiate execution of the program. The program is then run as

described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example initiation of execution is as follows, assuming a data file had previously been prepared:

```
HIS SERIES 600 ON 03/04/81 AT 13.301 CHANNEL 5647
USER ID - ROKACASECON
PASSWORD - XXXXXXXXXXXXXX
SYSTEM? FORT NEW
READY
*RUN WESLIB/CORPS/XØØ7Ø,R
```

CDC, Cybernet System

The log-on procedure is followed by a call to the CORPS procedure file

OLD, CORPS/UN=CECELB

to access the CORPS Library. The file name of the program is used in the command

BEGIN,,CORPS,XØØ7Ø

to initiate execution of the program. An example is:

```
S4/01/25 10.32.51  AC2E5DA
EASTERN CYBERNET CENTER SN487 NOS        1.4/531.281/20AD
FAMILY: KOE
USER NAME: CEROC2
PASSWORD -
XXXXXXX
TERMINAL:     510, NAMIAF
RECOVER/CHARGE: CHARGE, CEXXXXX, YYYYYY
/OLD, CORPS/UN=CECELB
/BEGIN,,CORPS/XØØ7Ø
```

Local District Harris Systems

After the user has signed on the system, the command to execute the CORPS program will be

*CORPS,XØØ7Ø

An example to illustrate the logon and execution procedure on one Harris 500 is shown below. There may be some differences at some local Corps sites.

```
"ACOE - VICKSBURG"
USER #? NNNNWES WESXXX

** Good Morning   25 Jan 84   9:56:31
VED HARRIS 500

*CORPS,XØØ7Ø
```

How to Use CORPS

The CORPS system contains many other useful programs which may be catalogued from CORPS by use of the LIST command. The execute command for CORPS on the WES system is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

On the Cybernet system, the commands are:

```
OLD,CORPS/UN=CECELB
BEGIN,,CORPS,CORPS
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

On the Harris local systems, the commands are:

```
*CORPS

ARE YOU USING A PRINTER TERMINAL OR CRT?
ENTER P OR C
C

ENTER COMMAND (BRIEF,EXECUTE,LIST,HELP,STOP):
LIST
```

PREFACE

This user's guide describes a computer program called CSHTSSI that can be used for soil-structure analysis of sheet pile retaining walls. The work in writing the computer program and the user's guide was accomplished with funds provided to the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., by the Civil Works Research and Development Program of the Office, Chief of Engineers, U. S. Army (OCE), under the Structural Engineering Research Program work unit of the Soil-Structure Interaction (SSI) Studies Project.

The computer program and user's guide were written by Dr. William P. Dawkins, P.E., of Stillwater, Okla., under Contract DACW39-81-M-0715 with WES.

Dr. N. Radhakrishnan, Special Technical Assistant, Automatic Data Processing (ADP) Center, WES, and SSI Studies Project Manager, coordinated and monitored the work. Messrs. H. Wayne Jones and Reed L. Mosher, Computer-Aided Design Group, provided technical assistance in developing and evaluating the program. Mr. Donald L. Neumann was Chief of the ADP Center. Mr. Donald R. Dressler was the point of contact in OCE.

Commanders and Directors of WES during the development of this program were COL N. P. Conover, CE, and COL T. C. Creel, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	0.0254	meters
kips (1000 lb force) per square inch	6.894757	megapascals
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (force) per square inch per foot	22.62059383	kilopascals per meter
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
pounds (mass) per cubic inch per foot	9081.332021	kilograms per cubic meter per meter
square inches	0.00064516	square meters

USER'S GUIDE: COMPUTER PROGRM FOR SOIL-STRUCTURE INTERACTION ANALYSIS OF SHEET PILE RETAINING WALLS (CSHTSSI)

PART I: INTRODUCTION

General Program Description

1. This report describes a computer program--CSHTSSI- r soil-structure interaction analysis of sheet pile retaining walls s described subsequently, the model employed for analysis of t. wall-soil system is a special case of a general beam-column. Hence, CSHTSSI is a special-purpose application of the general-purpose, beam-column analysis program CBEAMC.**

2. The relationship between forces exerted on the wall by the soil and wall displacements is described by Haliburton (1971).† Simplified procedures are incorporated in CSHTSSI to generate the soil force-displacement characteristics from soil properties provided as input.

Organization of Report

3. The remainder of this report is organized as follows:

a. Part II: Describes the wall-soil system.

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* CSHTSSI is designated X0070 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library. Three sheets entitled "PROGRAM INFORMATION" have been hand-inserted inside the front cover. They present general information on CSHTSSI and describe how it can be accessed. If procedures used to access this and other CORPS programs should change, recipients of this report will be furnished revised versions of the "PROGRAM INFORMATION" sheets.

** W. P. Dawkins. 1982. "User's Guide: Computer Program for Analysis of Beam-Column Structures with Nonlinear Supports (CBEAMC)," Instruction Report K-82-6, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

† T. A. Haliburton. 1971. "Soil-Structure Interaction," Technical Publication No. 14, School of Civil Engineering, Oklahoma State University, Stillwater, Okla.

b. Part III: Presents the procedures employed to generate nonlinear pressure-displacement curves from soils data.

c. Part IV: Outlines the method of solution.

d. Part V: Provides example solutions obtained with the program.

Remarks

4. CSHTSSI has been checked for computational accuracy within reasonable limits. However, there may exist unusual situations which were not anticipated which may cause the program to produce questionable results. It is the responsibility of the user to use good engineering judgment to determine the validity of the results, and no responsibility is assumed for the performance of any structure designed on the basis of results obtained with the program.

5. In particular, because only simplified soil pressure-displacement characteristics are used, CSHTSSI is intended only to demonstrate the soil-structure interaction (SSI) effect and to provide a means for comparison of SSI solutions with those obtained from classical methods of analysis for sheet pile walls. CSHTSSI is not to be construed as a general-purpose program and is not intended to serve as a basis for design.

PART II: WALL-SOIL SYSTEM

6. The wall-soil system considered for analysis is shown in Figure 1. Characteristics and assumptions for each of the system components are described below.

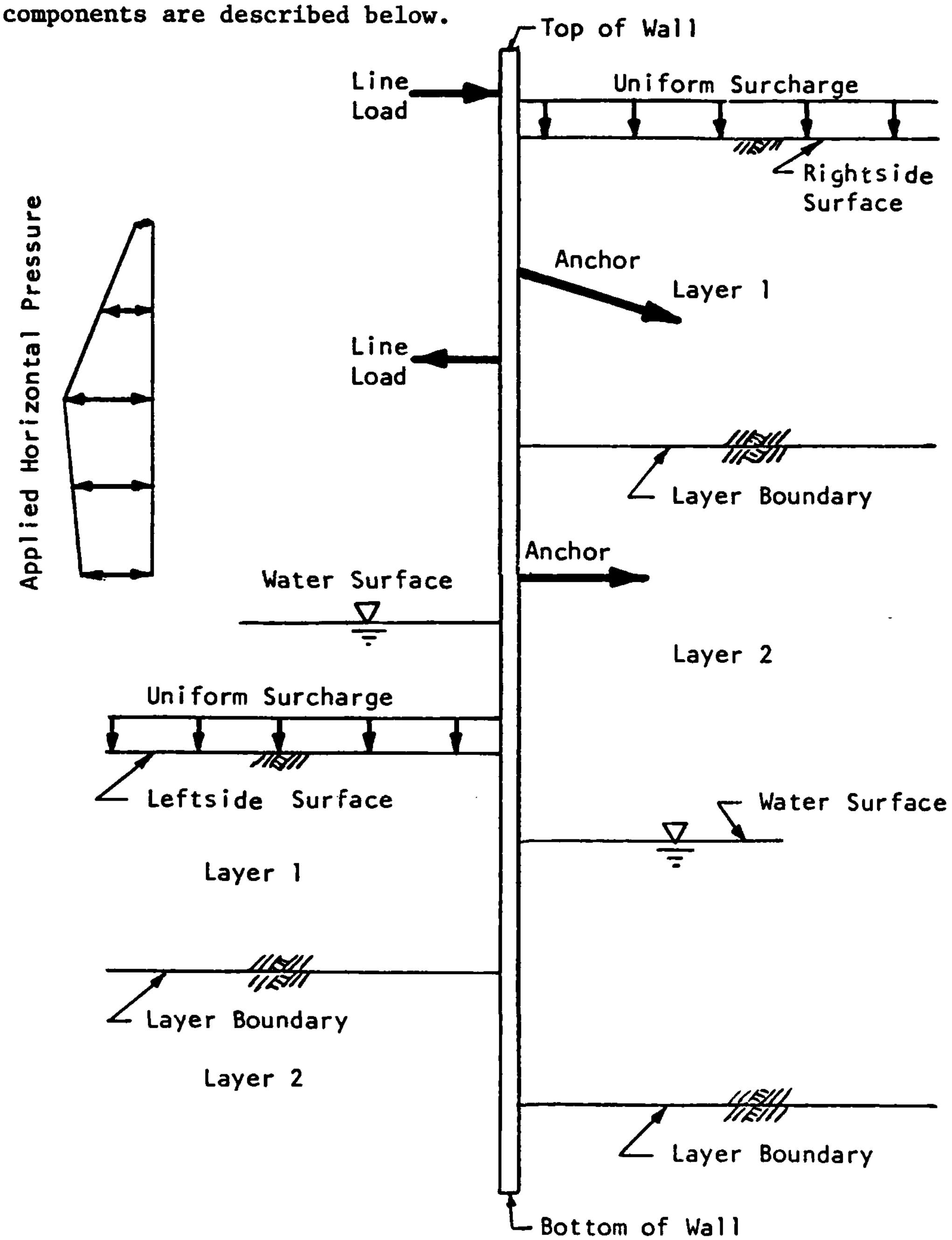


Figure 1. General wall-soil system

Wall

7. A 1-ft* slice of a straight, initially vertical, prismatic, lineraly elastic wall is assumed. The top and bottom elevations of the wall and wall section properties (modulus of elasticity, moment of inertia, and cross-sectional area) must be provided as input.

Anchors

8. Anchors are implicitly assumed to be attached to the right side of the wall and to extend to the right away from the wall. The anchor cross-sectional area is assumed to be an average for the 1-ft slice of wall. Four types of anchors are provided:

a. Tension-Only: Behave as elasto-plastic springs in resisting tension; are ineffective in resisting compression.

b. Rigid: Prevent horizontal motion of the point of attachment.

c. Compression-Only: Behave as elasto-plastic springs in resisting compression; are ineffective in resisting tension.

d. Tension-or-Compression: Behave as elasto-plastic springs in resisting either tension or compression.

Flexible anchors may be inclined to the vertical axis of the wall.

Soil

9. A stratified soil profile composed of horizontal, homogeneous layers is assumed to exist on each side of the wall. Properties required for description of each soil layer are discussed in Part III.

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented in page 3.

Water

10. Water surfaces may be at any elevation on either side of the wall. Water has the dual effect of producing lateral loads directly on the wall and of altering the effective unit weight of submerged soil and thus the pressure-displacement behavior of the soil.

Surcharges

11. A uniform surcharge is permitted on the soil surface on either side of the wall.

Additional Horizontal Loads

12. In addition to water loads which are generated automatically, two types of horizontal loads may be applied directly to the wall. Positive horizontal loads are assumed to act to the left. Horizontal line loads may be applied at any elevation. A horizontal pressure distribution may be applied to any length of the wall. The horizontal pressure distribution is described by a sequence of elevation and pressure values: the distribution is assumed to vary linearly between adjacent points.

PART III: SOIL FORCE-DISPLACEMENT BEHAVIOR

13. In classical procedures for design of sheet pile walls, soil pressures are assumed to be either "active" (wall moves away from soil), "passive" (wall moves into soil), or "at-rest" (wall does not move). These limit states of pressure are assumed to act without regard to the magnitude (and frequently direction) of wall displacement.

14. The procedures employed in CSHTSSI are simplifications of more detailed methods described by Haliburton (1971) for estimating the displacements at which ultimate active and passive pressures occur and for approximating the relationship between soil pressure and wall displacement intermediate to the extremes.

Limit State Soil Pressures

15. Limit state (active, at-rest, and passive) soil pressures are obtained from conventional soil mechanics theories as outlined below:

a. The vertical soil pressure, σ_v, at any point is calculated from the effective weight of the soil above the point and the uniform surface surcharge.

b. The ultimate active pressure at a point (point moves away from the soil) is

$$p_A = \sigma_v K_A - 2C\sqrt{K_A}$$

where

C = soil cohesion

K_A = active pressure coefficient given by

$$K_A = \left[\frac{\cos\phi}{1 + \sqrt{\frac{\sin(\phi + \delta)\sin\phi}{\cos\delta}}}\right]^2 \frac{1}{\cos\delta}$$

ϕ = angle of internal soil friction

δ = angle of wall-soil friction

(Note: For some cohesive soils the above equation may result in a negative [soil in tension] active pressure

at a point. When this situation is encountered, the active pressure is set to zero in CSHTSSI.)

c. At-rest pressure (zero displacement at a point) is

$$p_o = \sigma_v K_o$$

where

K_o = at-rest pressure coefficient

d. Ultimate passive pressure at a point (point moves into soil) is

$$p_P = \sigma_v K_P + 2C\sqrt{K_P}$$

where

K_P = passive pressure coefficient given by

$$K_P = \left[\frac{\cos\phi}{1 - \sqrt{\frac{\sin(\phi+\delta)\sin\phi}{\cos\delta}}}\right]^2 \frac{1}{\cos\delta}$$

16. Representative values of angle of internal friction ϕ, cohesion C, and at-rest pressure coefficient K_o are given by Haliburton (1971).

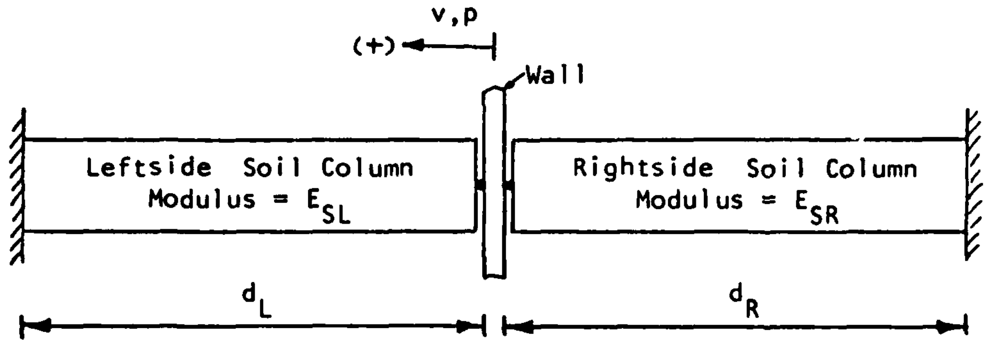
Soil Pressure-Displacement Behavior

17. Estimation of the variation of soil pressure with displacement between the limit states described above is based on two assumptions:

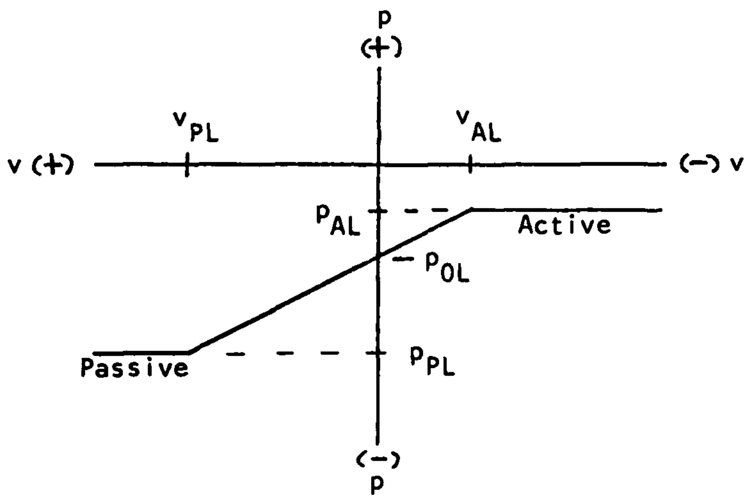
a. The pressure at a point depends only on the horizontal displacement of that point (i.e., the Winkler hypothesis).

b. The pressure varies linearly with displacement between ultimate active and passive extremes. (A simplification of the process described by Haliburton (1971).)

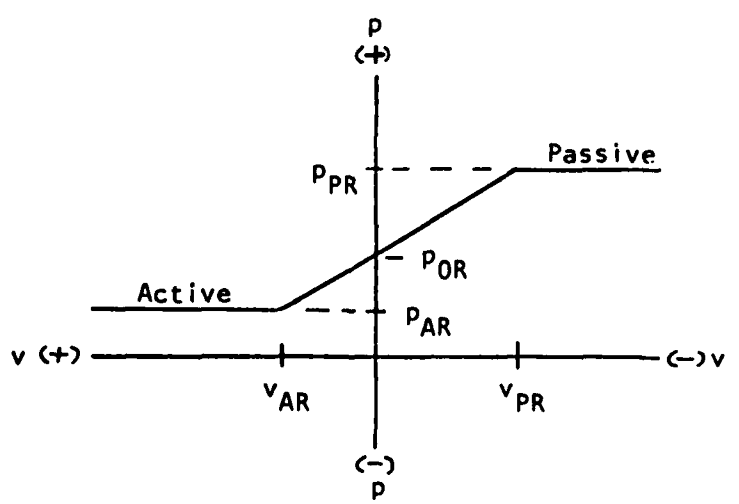
18. The pressure-displacement variation is obtained from ordinary engineering mechanics analysis of an elasto-plastic column of soil attached to a point on the wall. Typical soil columns are shown in Figure 2a. Each soil column is prismatic (unit cross-sectional area) and



a. Typical soil columns



b. Leftside soil



c. Rightside soil

Figure 2. Soil pressure-displacement variations

is fixed against horizontal translation at a distance d from the wall.

19. The following behavior for each soil column is observed:

a. At zero wall displacement ($v = 0$), each soil column exerts at-rest pressure on the wall. For positive pressure acting to the left, the at-rest condition corresponds to points p_O on the pressure-displacement axes shown in Figures 2b and c.

b. As the wall moves to the left (v positive) the pressure in the rightside column continues to act to the left (positive pressure) but the pressure magnitude decreases with increasing displacement until active pressure p_{AR} is reached at displacement v_{AR} (Figure 2b). For positive displacements greater than v_{AR}, the pressure in the rightside column remains constant at p_{AR}. Simultaneously, the pressure in the leftside column increases in magnitude (still acting to the right; i.e., negative) until passive pressure p_{PL} for the soil on that side is reach at displacement v_{PL}.

c. If the wall moves to the right (negative displacement), the soil pressure increases to passive on the right side and decreases to active on the left side. The pressures continue to act on the wall to the left (positive) due to the rightside soil and to the right (negative) due to the leftside soil.

20. The displacements at ultimate pressures for soil on either side are obtained from

$$v_A = (p_o - p_A) \cdot d/E_s$$

$$v_P = (p_o - p_P) \cdot d/E_s$$

where

d = length of soil column (interaction distance)

E_s = soil modulus

Soil Moduli

21. The soil modulus used for estimating pressure-displacement variation described above depends on the type of soil at each location. For clay ($\phi = 0$), the soil modulus is assumed to be constant throughout a layer. For sand ($C = 0$), the soil modulus is assumed to

vary linearly with depth and is obtained from

$$E_s = K_s \sigma_v / \gamma$$

where

K_s = sand modulus coefficient

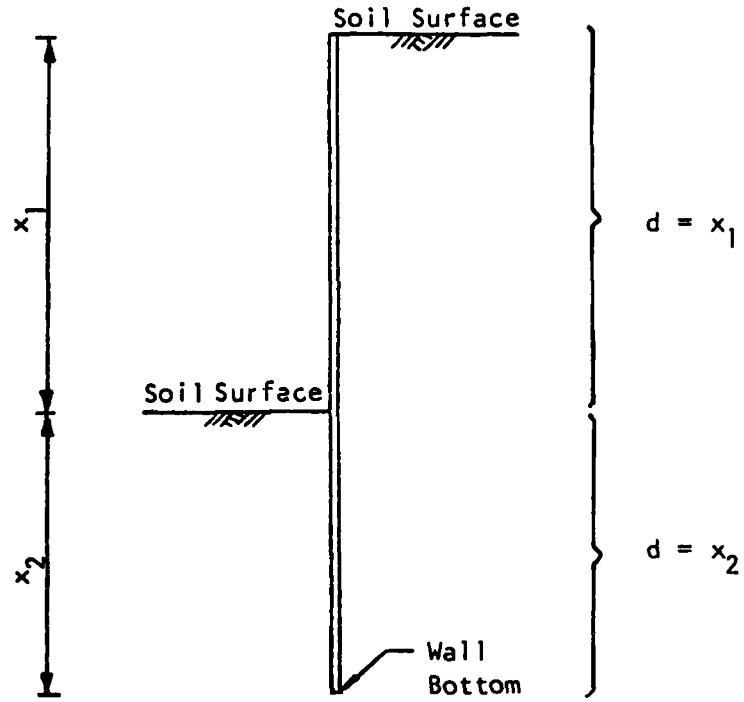
σ_v = vertical soil pressure

γ = effective soil unit weight

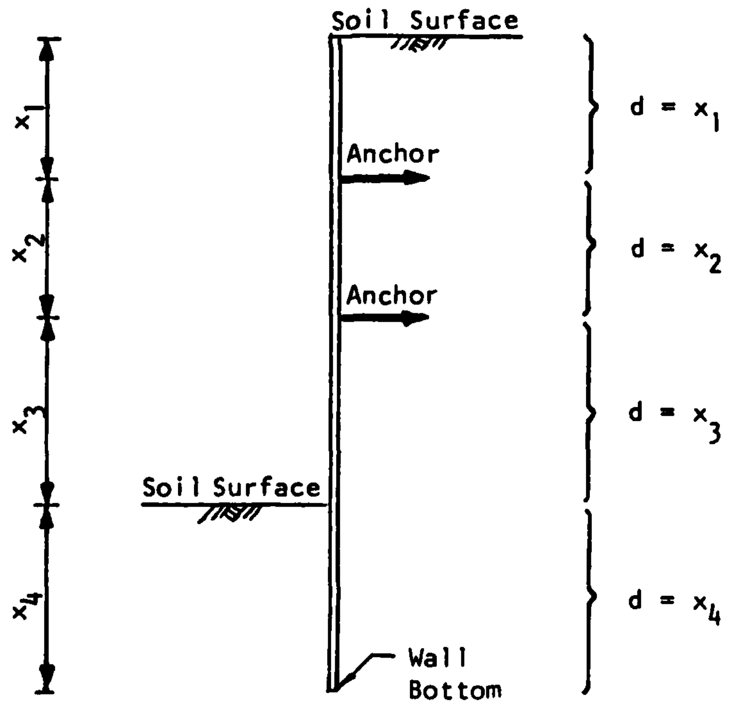
22. Representative values of E_{sc} for clay (ϕ = 0) and K_s for sand (C = 0) are given by Haliburton (1971). Soil moduli have not been established for soils possessing both cohesion and internal friction ("C - ϕ" soils). It is assumed in CSHTSSI that the modulus E_{sc} provided as input for C - ϕ soils is constant throughout the soil layer. Values of E_{sc} and K_s given by Haliburton (1971) are indicated to have units of pounds per cubic inch or tons per cubic foot. However, the values also include an implicit additional factor "per foot of interaction depth." CSHTSSI adjusts the input values for E_{sc} and K_s to account for this implicit factor as discussed in Part V.

Interaction Distance

23. The length d (interaction distance) of the soil columns described above (see also Figure 2) reflects the extent (distance away from the wall) of significantly stressed soil at the location of the column (e.g., the "pressure bulb" depth below a strip footing). There is no method for calculating the interaction distance. It has been demonstrated that the magnitude of the interaction distance is most significant in areas where soil pressures tend toward the passive state, while zones of active pressure are relatively unaffected by this parameter. Suggestions for initial estimates of interaction distances are shown in Figure 3.



a. Cantilever walls



b. Anchored walls

Figure 3. Initial estimates of interaction distance

PART IV: METHOD OF SOLUTION

24. The wall-soil system is analyzed, using the general-purpose beam-column program CBEAMC (Dawkins 1982), as a beam-column on distributed nonlinear supports possessing the soil pressure-displacement characteristics and concentrated nonlinear supports representing anchors (see below).

Input Phase

25. CSHTSSI accepts input data in a form convenient for describing the wall-soil system. These data are converted to a description of a beam-column on nonlinear supports as follows.

Wall Model

26. A one-dimensional finite element model of the wall is established by defining nodes at the following locations:

a. At the top of the wall.

b. At the location of each soil layer boundary for both rightside and leftside soil profiles.

c. At the location of the water level on each side.

d. At the location of each anchor.

e. At the location of each applied horizontal line load.

f. At the location of each input point on an applied horizontal pressure distribution.

g. At the wall bottom.

h. At equally spaced intervals between the above locations not exceeding 6 in.

Distributed Supports

27. The soil on each side of the wall is represented by distributed nonlinear supports resisting lateral motion of the wall. Soil pressure-displacement curves (Figure 2) are determined at the following locations:

a. At the top and bottom of each soil layer.

b. Immediately above and below the water elevation on each side of the wall.

c. At points where active soil pressures are set to zero (see paragraph 15, Part III).

28. Pressure-displacement characteristics at a point intermediate to the above are obtained from linear interpolation between curves at locations bounding the point.

Concentrated Supports (Anchors)

29. Anchors are treated as either rigid supports (lateral displacements only) or as concentrated nonlinear springs. Force-deformation behavior for each type of anchor is determined as shown in Figure 4.

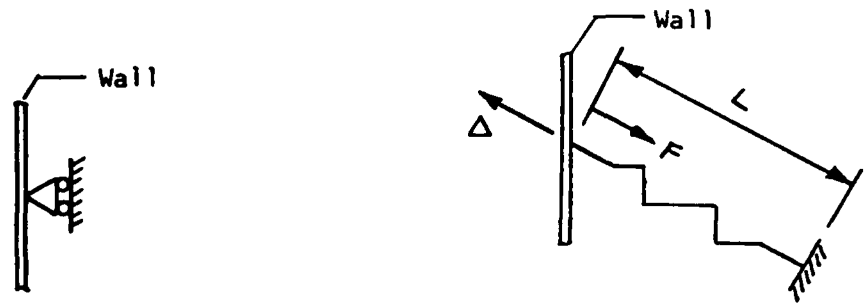
Iterative Solutions

30. As explained in Dawkins (1982), a solution for a nonlinear system is obtained from repeated trial-correction solutions until the results from two successive iterations agree within a prescribed tolerance. For most wall-soil systems convergence to a final solution is obtained with fewer than ten iterations. If a convergent solution is not obtained in twenty iterations, the user is notified and offered the opportunity to specify additional iterations or to terminate the solution process at that point.

Nonconvergent Solutions

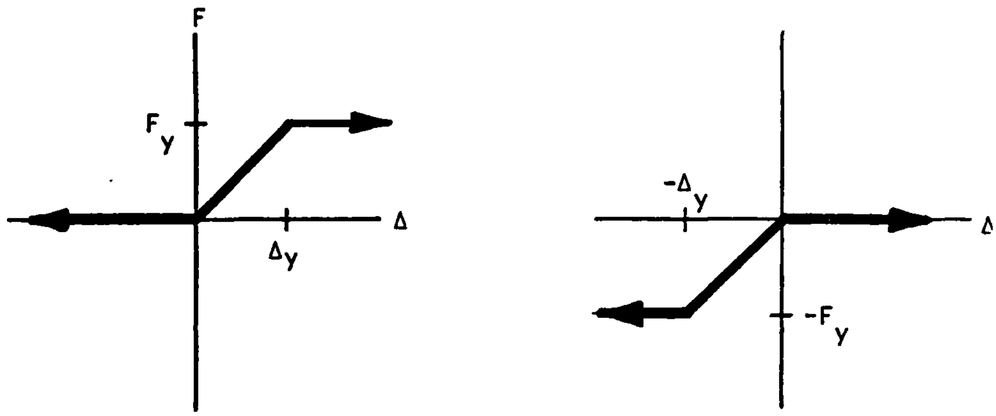
31. Even though additional iterations (greater than 20) are permitted, it is unlikely that convergency will be attained. The results reported by CSHTSSI for nonconvergent systems are UNRELIABLE. Nonconvergent solutions may result when:

a. The penetration, distance between the lower (leftside or



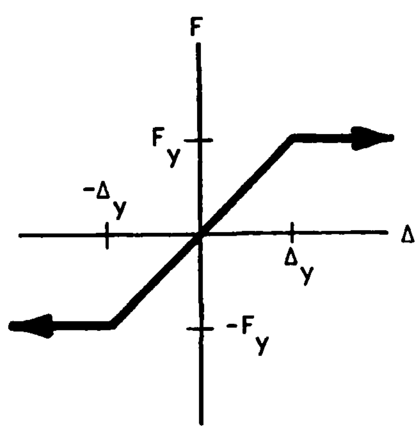
a. Rigid anchor

b. Flexible anchor



c. Tension-only anchor

d. Compression-only anchor



e. Tension-or-compression anchor

L = anchor effective length
A = anchor cross-sectional area
E = anchor modulus of elasticity
f_y = anchor yield stress
F = anchor force
F_y = anchor yield force = $A \cdot f_y$
Δ = anchor deformation
Δ_y = anchor yield deformation
= $f_y \cdot L/E$

f. Definitions

Figure 4. Anchor spring characteristics

rightside) soil surface and wall bottom, is too small. This results in large lateral displacements so that few (if any) points on the wall continue to have finite soil stiffness (displacements between v_A and v_P, Figure 2).

b. When properties for tension-only, compression-only, or tension-or-compression anchors produce extremely high anchor stiffnesses (F_y/Δ_y, Figure 4). In this situation, small adjustments in displacements between successive iterations may result in oscillation from a high anchor stiffness (displacement less than Δ_y) to zero anchor stiffness (displacement greater than Δ_y). Convergent solutions for this case are not possible.

Output Phase

32. CSHTSSI reports a summary containing maximum displacements, bending moments, shears, axial forces, and anchor forces. The user is then offered the opportunity to output a complete table of response values containing displacements, axial forces, shears, bending moments, and soil pressures at 1-ft intervals (and other critical points) on the wall.

33. Sign conventions used for output are given in Table 1.

Table 1

Sign Conventions for CSHTSSI

Factor	Positive Result
Axial displacement	Downward
Lateral displacement	To left
Axial force	Compression
Shear force	Acts to right on top of segment of wall
Bending moment	Produces tension on left side of wall
Soil pressure	Acts to left on wall
Anchor force	Anchor in tension

PART V: EXAMPLE SOLUTIONS

34. The example solutions discussed below demonstrate the use of CSHTSSI. The wall section properties and penetrations for the first two examples were obtained from classical design procedures for these systems. The third example illustrates a potential use of SSI analysis for a system where no classical design procedure exists. In all cases, the soil modulus values for clay and sand were selected from Haliburton (1971) as representative of these soils.

Example 1--Cantilever Floodwall

35. The wall-soil system is shown in Figure 5. The penetration

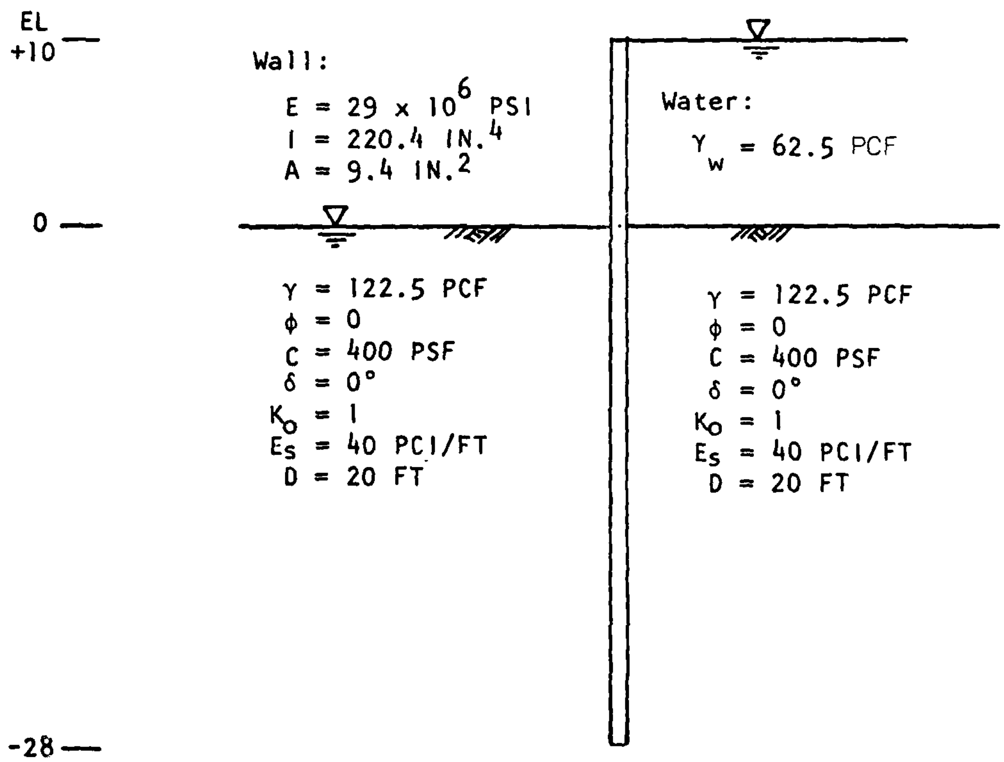


Figure 5. Wall-soil system for example 1

into the clay layer (28 ft) was determined from classical design procedures. The input file describing the system appears as follows:

```
1000 'CANTILEVER FLOODWALL DRIVEN IN CLAY
1010 'PENETRATION FROM CLASSICAL DESIGN
1020 WALL 10 -28 29.E6 220.4 9.4
1030 RIGHTSIDE
1040 0 122.5 0 400 0 1 40 20
1050 LEFTSIDE
1060 0 122.5 0 400 0 1 40 20
1070 WATER 62.5 10 0
1080 FINISH
```

The interactive execution sequence appears as follows:

```
    PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
    OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
    DATE: 02/07/83                        TIME: 09:00:07

    ARE INPUT DATA TO BE READ FROM TERMINAL OR FILE?
    ENTER 'TERMINAL' OR 'FILE'.
I>F
    ENTER INPUT FILE NAME (6 CHARACTERS MAXIMUM).
I>EX1
    INPUT COMPLETE.
    DO YOU WANT INPUT DATA ECHOPRINTED TO YOUR
    TERMINAL, TO A FILE, TO BOTH OR NEITHER?
    ENTER 'TERMINAL', 'FILE', 'BOTH', OR 'NEITHER'.
I>F
    ENTER OUTPUT FILE NAME (6 CHARACTERS MAXIMUM).
I>EX1OUT
    DO YOU WANT TO EDIT INPUT DATA?  ENTER 'YES' OR 'NO'.
I>N
    INPUT COMPLETE. DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
I>Y
    DO YOU WANT A LISTING OF NONLINEAR SPRING DATA GENERATED BY SHTSSI?
    ENTER 'YES' OR 'NO'.
I>Y
    DO YOU WANT TO CONTINUE?  ENTER 'YES' OR 'NO'.
I>Y

    DO YOU WANT AXIAL FORCE EFFECTS ON BENDING STIFFNESS INCLUDED
    IN THE SOLUTION?  ENTER 'YES' OR 'NO'
I>Y
    SOLUTION COMPLETE.
    DO YOU WANT RESULTS WRITTEN TO YOUR TERMINAL,
    TO FILE 'EX1OUT', OR BOTH?
    ENTER 'TERMINAL', 'FILE', OR 'BOTH'.
I>F

    DO YOU WANT COMPLETE RESULTS OUTPUT? ENTER 'YES' OR 'NO'.
I>Y
    DO YOU WANT TO PLOT RESULTS
    ENTER 'YES' OR 'NO'
I>Y
    ORIGINAL UNITS ARE IN 'INCHES' AND 'POUNDS'
    DO YOU WANT TO CHANGE DATA UNITS FOR PLOTS ONLY?
    ENTER 'Y' OR 'N'
I>N
```

Figure 6 shows plots of the results for example 1.

36. Output is shown in the printouts described below and consists of:

a. PART I: An echoprint (optional) of the input data (page 24).

b. PART II: A listing (optional) of nonlinear spring data generated by CSHTSSI for flexible anchors and soil (page 25).

c. PART III: A summary of results (page 26).

d. PART IV: Complete results (optional) (page 26).

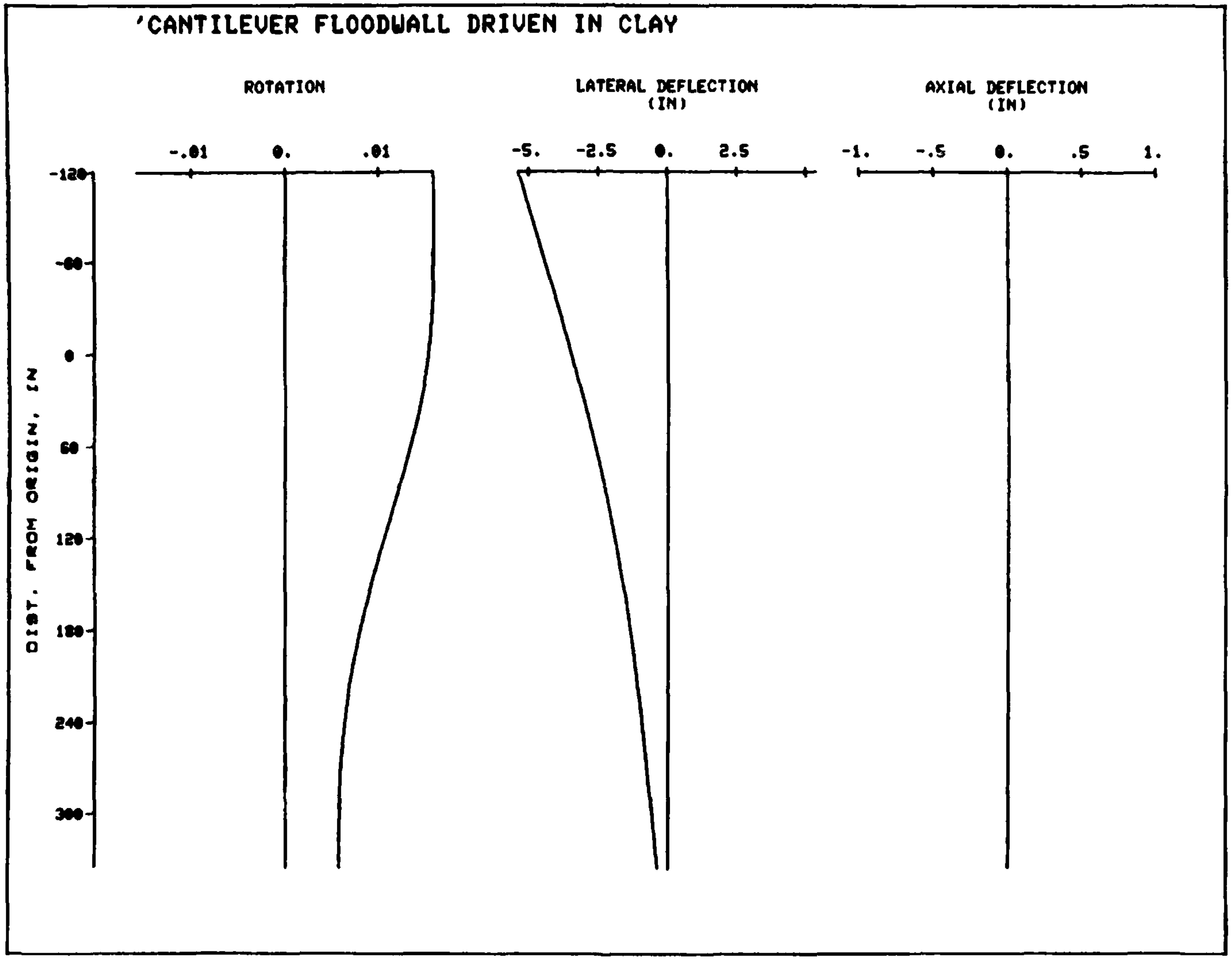


Figure 6. Plots of results for example 1 (Sheet 1 of 3)

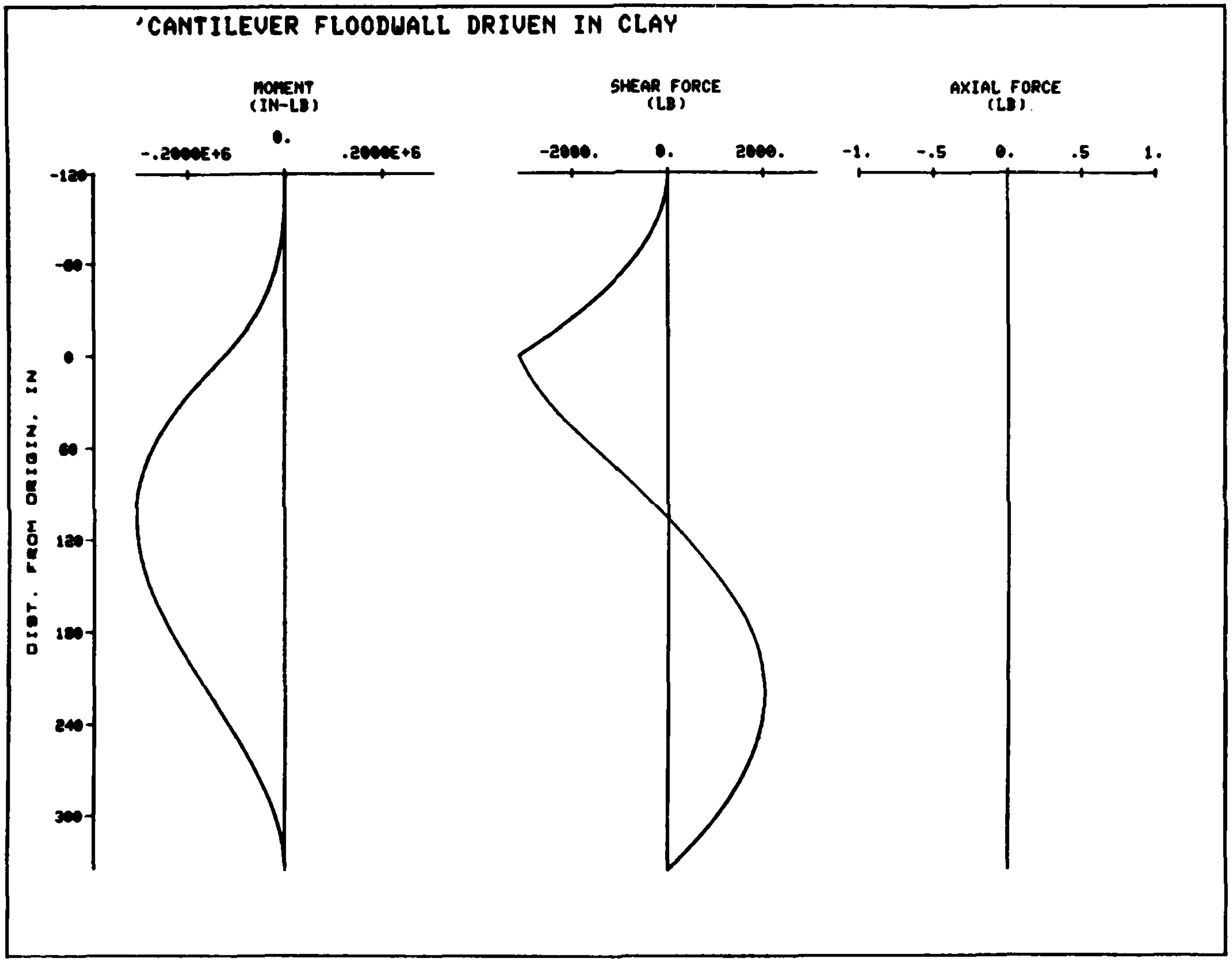


Figure 6. (Sheet 2 of 3)

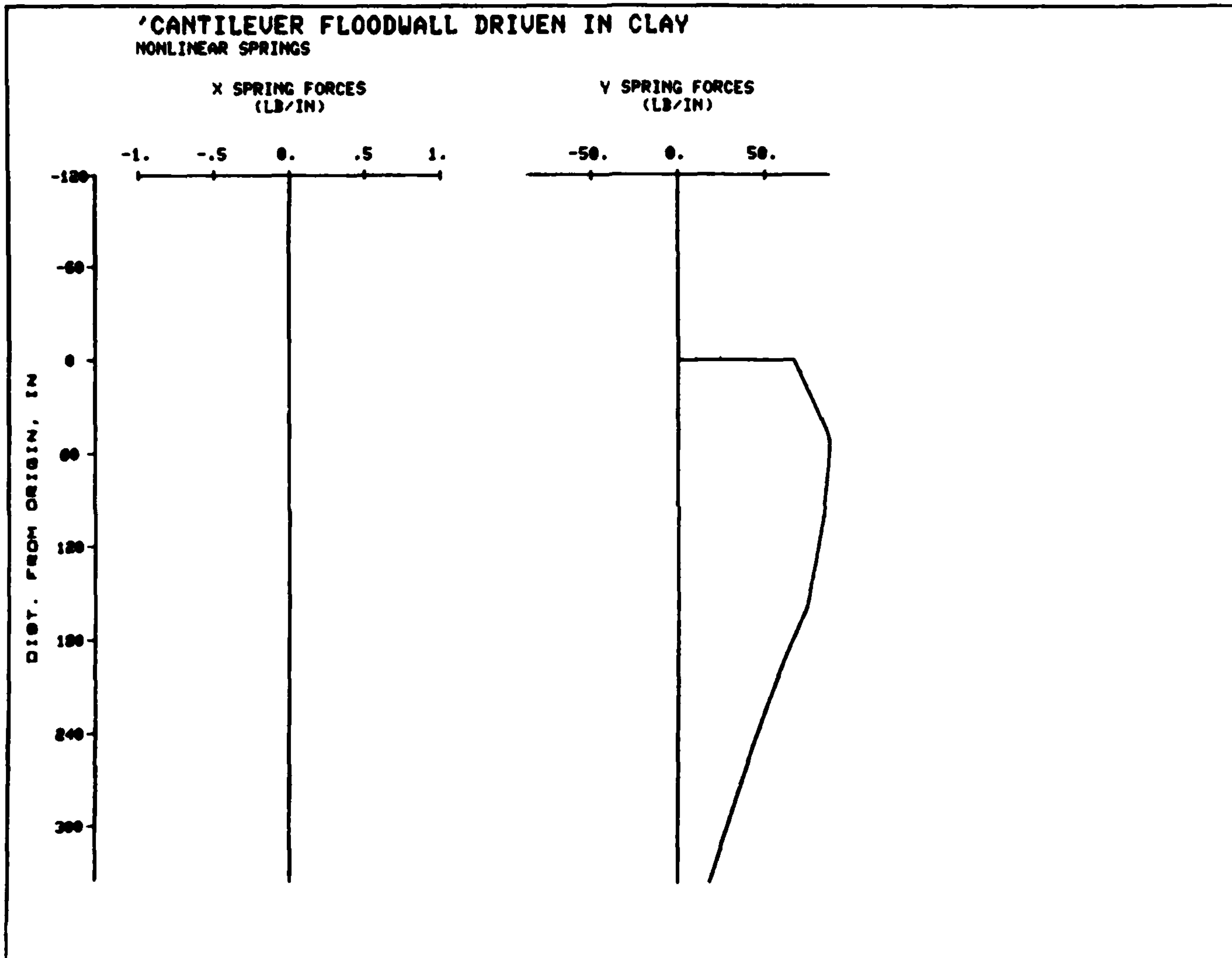


Figure 6. (Sheet 3 of 3)

PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/07/83 TIME: 09:21:22

I.--INPUT DATA

1.--HEADING

'CANTILEVER FLOODWALL DRIVEN IN CLAY
'PENETRATION FROM CLASSICAL DESIGN

2.--WALL DATA

ELEVATION AT TOP OF WALL	=	10.00	(FT)
ELEVATION AT BOTTOM OF WALL	=	-28.00	(FT)
WALL MODULUS OF ELASTICITY	=	29.0E+06	(PSI)
WALL MOMENT OF INERTIA	=	220.40	(IN**4)
WALL CROSS SECTION AREA	=	9.40	(SQIN)

3.--ANCHOR DATA
NONE

4.--RIGHTSIDE SOIL DATA

LAYER NO	TOP ELEV AT WALL (FT)	UNIT WEIGHT (PCF)	INTERN FRICT (DEG)	COH- HESION (PSF)	WALL FRICT (DEG)	AT-REST COEFF	SOIL MODULUS (PCI)	INTERACT DISTANCE (FT)
1	0.00	122.50	0.00	400.00	0.00	1.00	40.00	20.00

5.--LEFTSIDE SOIL DATA

LAYER NO	TOP ELEV AT WALL (FT)	UNIT WEIGHT (PCF)	INTERN FRICT (DEG)	COH- HESION (PSF)	WALL FRICT (DEG)	AT-REST COEFF	SOIL MODULUS (PCI)	INTERACT DISTANCE (FT)
1	0.00	122.50	0.00	400.00	0.00	1.00	40.00	20.00

6.--WATER DATA

WATER UNIT WEIGHT	=	62.50	(PCF)
RIGHTSIDE WATER ELEVATION	=	10.00	(FT)
LEFTSIDE WATER ELEVATION	=	0.00	(FT)

7.--SURFACE SURCHARGE LOADS
NONE

8.--HORIZONTAL LINE LOADS
NONE

9.--HORIZONTAL APPLIED PRESSURES
NONE

```
PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/07/83                           TIME: 09:21:37

II.--NONLINEAR CURVE DATA GENERATED BY CSHTSSI

II.A.--HEADING
  'CANTILEVER FLOODWALL DRIVEN IN CLAY
  'PENETRATION FROM CLASSICAL DESIGN


II.B.--ANCHOR NONLINEAR SPRING DATA
     NONE


II.C.--RIGHTSIDE SOIL NONLINEAR SPRING DATA


     ELEVATION       0.00 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  1.0000E+03  0.              -2.3148E-01
               PRESSURE (PSF)   :        0.00           0.00       800.00


     ELEVATION     -13.33 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -2.3148E-01
               PRESSURE (PSF)   :        0.00         800.00      1600.00


     ELEVATION     -13.33 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -2.3148E-01
               PRESSURE (PSF)   :        0.00         800.00      1600.00


     ELEVATION     -28.00 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -2.3148E-01
               PRESSURE (PSF)   :      880.00        1680.00      2480.00


II.D.--LEFTSIDE SOIL NONLINEAR SPRING DATA

     ELEVATION       0.00 (FT)         PASSIVE       AT-REST       ACTIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -1.0000E+03
               PRESSURE (PSF)   :     -800.00           0.00         0.00

     ELEVATION     -13.33 (FT)         PASSIVE       AT-REST       ACTIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -2.3148E-01
               PRESSURE (PSF)   :    -1600.00        -800.00         0.00

     ELEVATION     -13.33 (FT)         PASSIVE       AT-REST       ACTIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -2.3148E-01
               PRESSURE (PSF)   :    -1600.00        -800.00         0.00

     ELEVATION     -28.00 (FT)         PASSIVE       AT-REST       ACTIVE
               DISPLACEMENT (FT):  2.3148E-01  0.              -2.3148E-01
               PRESSURE (PSF)   :    -2480.00       -1680.00      -880.00
```

PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/07/83 TIME: 09:21:55

III.--SUMMARY OF RESULTS

III.A.--HEADING
'CANTILEVER FLOODWALL DRIVEN IN CLAY
'PENETRATION FROM CLASSICAL DESIGN

III.B.--MAXIMA

	MAXIMUM POSITIVE	ELEV (FT)	MAXIMUM NEGATIVE	ELEV (FT)
AXIAL DISPLACEMENT (IN) :	0.	0.00	0.	0.00
LATERAL DISPLACEMENT (IN):	5.39E+00	10.00	0.	0.00
AXIAL FORCE (LB) :	0.	0.00	0.	0.00
SHEAR (LB) :	2.03E+03	-18.22	-3.13E+03	0.00
BENDING MOMENT (LB-FT) :	0.	0.00	-2.55E+04	-8.89

IV.--COMPLETE RESULTS

IV.A.--HEADING
'CANTILEVER FLOODWALL DRIVEN IN CLAY
'PENETRATION FROM CLASSICAL DESIGN

IV.B.--COMPLETE RESULTS

ELEV (FT)	<----DEFLECTIONS---> AXIAL (IN)	LATERAL (IN)	AXIAL FORCE (LB)	SHEAR (LB)	BENDING MOMENT (LB-FT)	SOIL PRESSURE (PSF)
10.00	0.	5.39E+00	0.	0.	0.	0.00
9.00	0.	5.20E+00	0.	-31.	-10.	0.00
8.00	0.	5.01E+00	0.	-125.	-83.	0.00
7.00	0.	4.82E+00	0.	-281.	-281.	0.00
6.00	0.	4.63E+00	0.	-500.	-667.	0.00
5.00	0.	4.44E+00	0.	-781.	-1302.	0.00
4.00	0.	4.25E+00	0.	-1125.	-2250.	0.00
3.00	0.	4.06E+00	0.	-1531.	-3573.	0.00
2.00	0.	3.87E+00	0.	-2000.	-5333.	0.00
1.00	0.	3.69E+00	0.	-2531.	-7594.	0.00
0.00	0.	3.50E+00	0.	-3125.	-10417.	0.00
0.00	0.	3.50E+00	0.	-3125.	-10417.	-800.00
-1.00	0.	3.32E+00	0.	-2920.	-13443.	-860.00
-2.00	0.	3.14E+00	0.	-2655.	-16235.	-920.00
-3.00	0.	2.97E+00	0.	-2329.	-18731.	-980.00
-4.00	0.	2.80E+00	0.	-1945.	-20872.	-1038.05
-5.00	0.	2.64E+00	0.	-1523.	-22605.	-1044.29
-6.00	0.	2.48E+00	0.	-1108.	-23919.	-1035.80
-7.00	0.	2.33E+00	0.	-703.	-24822.	-1023.38
-8.00	0.	2.19E+00	0.	-312.	-25328.	-1007.56
-9.00	0.	2.05E+00	0.	61.	-25451.	-968.84
-10.00	0.	1.92E+00	0.	415.	-25211.	-967.68
-11.00	0.	1.80E+00	0.	746.	-24628.	-944.49
-12.00	0.	1.68E+00	0.	1053.	-23726.	-919.63
-13.00	0.	1.57E+00	0.	1335.	-22530.	-893.38
-13.33	0.	1.54E+00	0.	1423.	-22077.	-884.40
-14.00	0.	1.47E+00	0.	1581.	-21068.	-844.97
-15.00	0.	1.37E+00	0.	1773.	-19386.	-788.41
-16.00	0.	1.28E+00	0.	1909.	-17540.	-734.86
-17.00	0.	1.19E+00	0.	1993.	-15585.	-684.03
-18.00	0.	1.10E+00	0.	2028.	-13570.	-635.64
-19.00	0.	1.02E+00	0.	2015.	-11545.	-589.35
-20.00	0.	9.46E-01	0.	1957.	-9555.	-544.87
-21.00	0.	8.71E-01	0.	1856.	-7645.	-501.87
-22.00	0.	7.99E-01	0.	1712.	-5857.	-460.06
-23.00	0.	7.28E-01	0.	1526.	-4234.	-419.17
-24.00	0.	6.58E-01	0.	1300.	-2817.	-378.95
-25.00	0.	5.89E-01	0.	1035.	-1645.	-339.16
-26.00	0.	5.20E-01	0.	729.	-759.	-299.64
-27.00	0.	4.52E-01	0.	384.	-197.	-260.24
-28.00	0.	3.83E-01	0.	0.	0.	-220.88

37. The following should be noted:

   a. Signs for the coordinates of the nonlinear soil springs are assigned according to direction (displacements and pressures positive to the left).

   b. Whenever at-rest pressure and either active or passive pressure are zero, an arbitrary value equal to 1000 ft is assigned to the displacement coordinate corresponding to the zero active or passive pressure (see leftside and rightside springs at elevation 0.00, page 25).

   c. The complete output contains two lines of information at each elevation where an abrupt change in any quantity occurs (see at elevation 0.00, page 26).

Example 2--Single-Anchored Retaining Wall

38. The wall-soil system is shown in Figure 7. The classical "free-earth" method for anchored wall design provided the required penetration (9 ft) into the clay layer. The input data file appears as follows:

```
1000 'ANCHORED RETAINING WALL DRIVEN IN CLAY
1010 'WITH SAND BACKFILL
1020 'PENETRATION FROM CLASSICAL 'FIXED EARTH' DESIGN
1030 WALL 8 -31 29.E6 220.4 9.4
1040 ANCHOR
1050 4 T 29.E6 40000 1 40 0
1060 RIGHTSIDE
1070 8 105 30 0 20 0.4 2.9 4
1080 0 128.5 30 0 20 0.6 15 22
1090 -22 122.5 0 1500 0 1 87 9
1100 LEFTSIDE
1110 -22 122.5 0 1500 0 1 87 9
1120 WATER 62.5 0 -4
1130 LINE 8 1000
1140 FINISH
```

Figure 8 shows plots of the results. The echoprint of input data is shown on page 32.

39. The listing of nonlinear curve data generated by CSHTSSI, shown on page 33, includes force-displacement data for the anchor and for the soil on each side of the wall. Deformation coordinates for the anchor curve are measured along the line of the anchor for inclined anchors and are positive if the point of attachment moves away from the fixed base of the anchor (i.e., anchor in tension).

40. The summary of results and complete results are shown on pages 33 and 34. The summary includes the anchor force. The effect of anchor force on the wall is also reflected in the wall shear force at

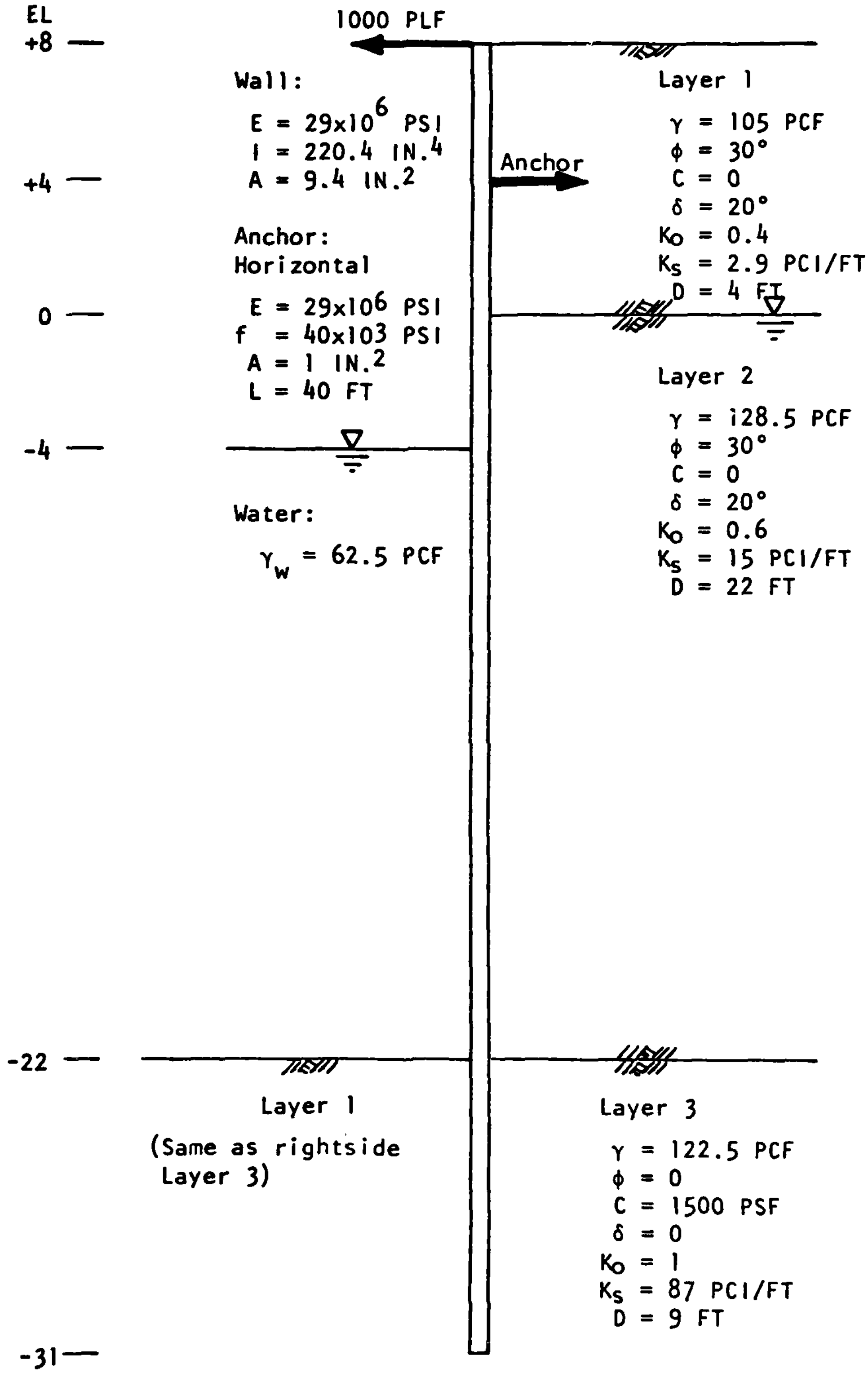


Figure 7. Wall-soil system for example 2

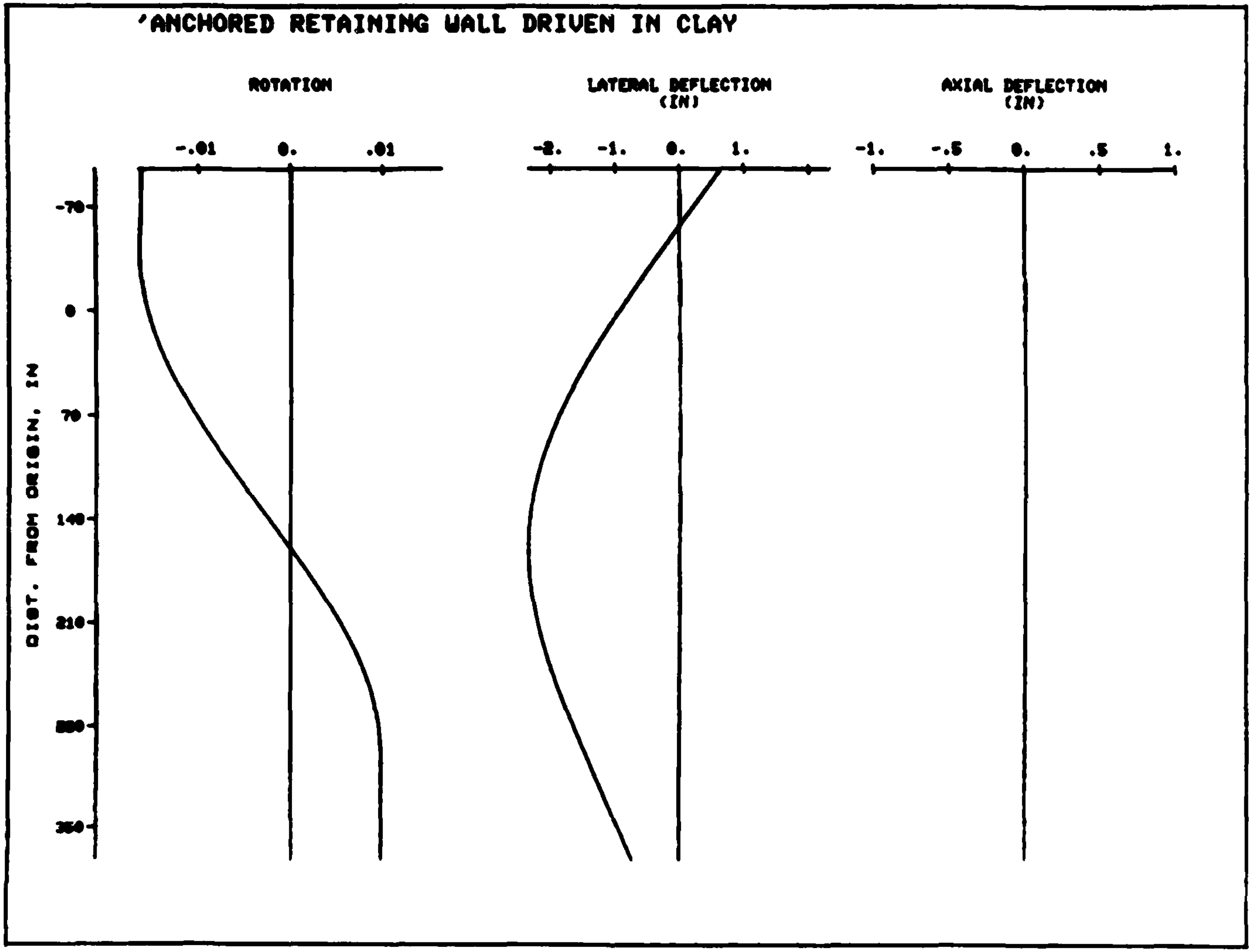


Figure 8. Plots of results for example 2 (Sheet 1 of 3)

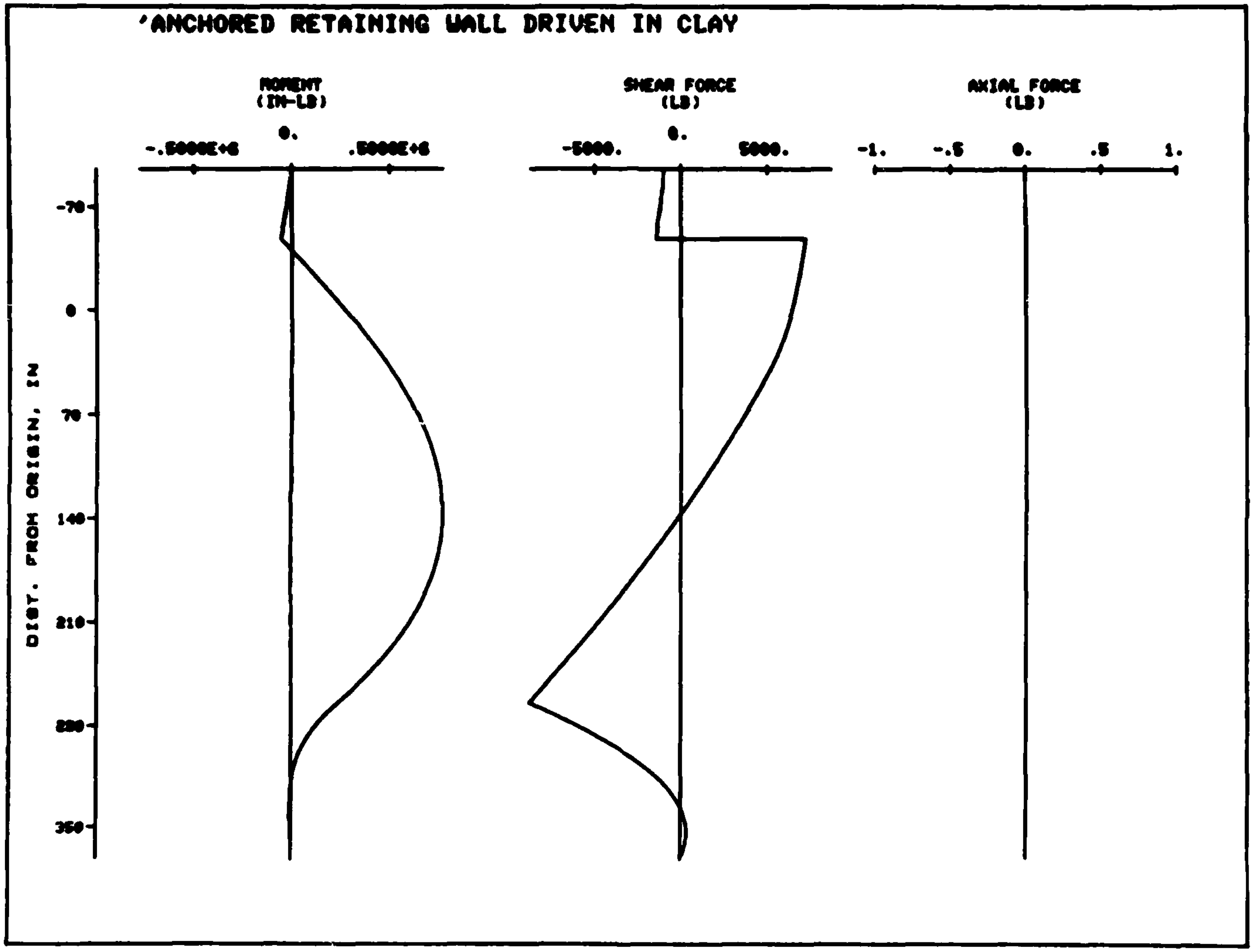


Figure 8. (Sheet 2 of 3)

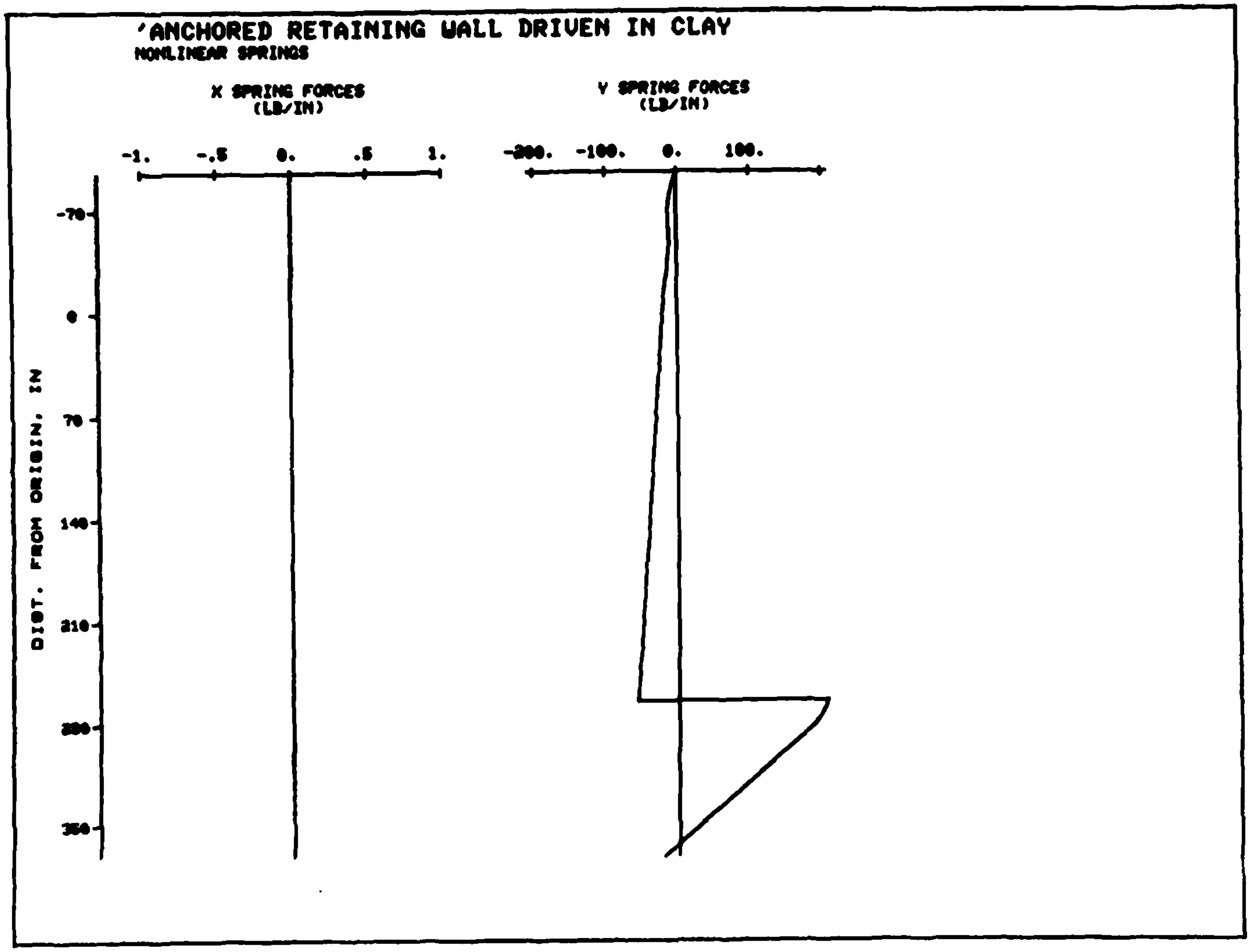


Figure 8. (Sheet 3 of 3)

PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/09/83 TIME: 13:47:06

I.--INPUT DATA

1.--HEADING

'ANCHORED RETAINING WALL DRIVEN IN CLAY
'WITH SAND BACKFILL
'PENETRATION FROM CLASSICAL 'FIXED EARTH' DESIGN

2.--WALL DATA

ELEVATION AT TOP OF WALL	=	8.00	(FT)
ELEVATION AT BOTTOM OF WALL	=	-31.00	(FT)
WALL MODULUS OF ELASTICITY	=	29.0E+06	(PSI)
WALL MOMENT OF INERTIA	=	220.40	(IN**4)
WALL CROSS SECTION AREA	=	9.40	(SQIN)

3.--ANCHOR DATA

ANCH NO	ELEV AT WALL (FT)	TYPE	MODULUS OF ELAST (PSI)	YIELD STRESS (PSI)	CROSS SECTION AREA (SQIN)	EFFECT LENGTH (FT)	SLOPE (FT/FT)
1	4.00	T	29.E+06	40000.	1.00	40.00	1: 0.00

4.--RIGHTSIDE SOIL DATA

LAYER NO	TOP ELEV AT WALL (FT)	UNIT WEIGHT (PCF)	INTERN FRICT (DEG)	COH-HESION (PSF)	WALL FRICT (DEG)	AT-REST COEFF	SOIL MODULUS (PCI)	INTERACT DISTANCE (FT)
1	8.00	105.00	30.00	0.00	20.00	.40	2.90	4.00
2	0.00	128.50	30.00	0.00	20.00	.60	15.00	22.00
3	-22.00	122.50	0.00	1500.00	0.00	1.00	87.00	9.00

5.--LEFTSIDE SOIL DATA

LAYER NO	TOP ELEV AT WALL (FT)	UNIT WEIGHT (PCF)	INTERN FRICT (DEG)	COH-HESION (PSF)	WALL FRICT (DEG)	AT-REST COEFF	SOIL MODULUS (PCI)	INTERACT DISTANCE (FT)
1	-22.00	[illegible]2.50	0.00	1500.00	0.00	1.00	87.00	9.00

6.--WATER DATA

WATER UNIT WEIGHT	=	62.50	(PCF)
RIGHTSIDE WATER ELEVATION	=	0.00	(FT)
LEFTSIDE WATER ELEVATION	=	-4.00	(FT)

7.--SURFACE SURCHARGE LOADS
NONE

8.--HORIZONTAL LINE LOADS

LOAD NO	ELEV AT WALL (FT)	LOAD (PLF)
1	8.00	1000.00

9.--HORIZONTAL APPLIED PRESSURES
NONE

```
PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/09/83                          TIME: 13:47:16

II.--NONLINEAR CURVE DATA GENERATED BY CSHTSSI

II.A.--HEADING
  'ANCHORED RETAINING WALL DRIVEN IN CLAY
  'WITH SAND BACKFILL
  'PENETRATION FROM CLASSICAL 'FIXED EARTH' DESIGN


II.B.--ANCHOR NONLINEAR SPRING DATA

     ANCHOR ELEV.      4.00 (FT)       TENSION     COMPRESSION
                                        YIELD         YIELD
                DEFORMATION (FT):  5.5172E-02      0.
                FORCE (LB)      :  4.0000E+04      0.

II.C.--RIGHTSIDE SOIL NONLINEAR SPRING DATA

     ELEVATION       8.00 (FT)        ACTIVE      AT-REST      PASSIVE
                DISPLACEMENT (FT):  1.0000E+03  0.             -1.0000E+03
                PRESSURE (PSF)   :        0.00        0.00          0.00

     ELEVATION       0.00 (FT)        ACTIVE      AT-REST      PASSIVE
                DISPLACEMENT (FT):  8.6064E-03  0.             -4.7818E-01
                PRESSURE (PSF)   :      249.74      336.00       5128.50

     ELEVATION       0.00 (FT)        ACTIVE      AT-REST      PASSIVE
                DISPLACEMENT (FT):  1.6956E-02  0.             -3.0840E-01
                PRESSURE (PSF)   :      249.74      504.00       5128.50

     ELEVATION     -22.00 (FT)        ACTIVE      AT-REST      PASSIVE
                DISPLACEMENT (FT):  1.6956E-02  0.             -3.0840E-01
                PRESSURE (PSF)   :      681.44     1375.20      13993.48

     ELEVATION     -22.00 (FT)        ACTIVE      AT-REST      PASSIVE
                DISPLACEMENT (FT):  1.3721E-01  0.             -1.7960E-01
                PRESSURE (PSF)   :        0.00     2292.00       5292.00

     ELEVATION     -31.00 (FT)        ACTIVE      AT-REST      PASSIVE
                DISPLACEMENT (FT):  1.6954E-01  0.             -1.7960E-01
                PRESSURE (PSF)   :        0.00     2832.00       5832.00

II.D.--LEFTSIDE SOIL NONLINEAR SPRING DATA

     ELEVATION     -22.00 (FT)        PASSIVE     AT-REST       ACTIVE
                DISPLACEMENT (FT):  1.7960E-01  0.             -1.0000E+03
                PRESSURE (PSF)   :    -3000.00        0.00          0.00

     ELEVATION     -31.00 (FT)        PASSIVE     AT-REST       ACTIVE
                DISPLACEMENT (FT):  1.7960E-01  0.             -3.2328E-02
                PRESSURE (PSF)   :    -3540.00     -540.00          0.00



PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/09/83                          TIME: 13:47:33

III.--SUMMARY OF RESULTS

III.A.--HEADING
  'ANCHORED RETAINING WALL DRIVEN IN CLAY
  'WITH SAND BACKFILL
  'PENETRATION FROM CLASSICAL 'FIXED EARTH' DESIGN
```

III.B.--MAXIMA

	MAXIMUM POSITIVE	ELEV (FT)	MAXIMUM NEGATIVE	ELEV (FT)
AXIAL DISPLACEMENT (IN) :	0.	0.00	0.	0.00
LATERAL DISPLACEMENT (IN):	2.34E+00	-13.50	-6.41E-01	8.00
AXIAL FORCE (LB) :	0.	0.00	0.	0.00
SHEAR (LB) :	7.23E+03	4.00	-8.76E+03	-22.00
BENDING MOMENT (LB-FT) :	6.45E+04	-11.50	-4.73E+03	4.00

III.C.--ANCHOR FORCES

ANCHOR ELEV (FT)	ANCHOR FORCE (LB)
4.00	8666.

IV.--COMPLETE RESULTS

IV.A.--HEADING

'ANCHORED RETAINING WALL DRIVEN IN CLAY
'WITH SAND BACKFILL
'PENETRATION FROM CLASSICAL 'FIXED EARTH' DESIGN

IV.B.--COMPLETE RESULTS

ELEV (FT)	<----DEFLECTIONS---> AXIAL (IN)	LATERAL (IN)	AXIAL FORCE (LB)	SHEAR (LB)	BENDING MOMENT (LB-FT)	SOIL PRESSURE (PSF)
8.00	0.	-6.41E-01	0.	-1000.	0.	0.00
7.00	0.	-4.45E-01	0.	-1048.	-1016.	88.49
6.00	0.	-2.50E-01	0.	-1163.	-2118.	136.15
5.00	0.	-5.36E-02	0.	-1306.	-3352.	142.79
4.00	0.	1.43E-01	0.	-1436.	-4726.	124.87
4.00	0.	1.43E-01	0.	7230.	-4726.	124.87
3.00	0.	3.41E-01	0.	7090.	2437.	156.09
2.00	0.	5.39E-01	0.	6918.	9443.	187.31
1.00	0.	7.33E-01	0.	6715.	16262.	218.53
0.00	0.	9.24E-01	0.	6481.	22863.	249.74
-1.00	0.	1.11E+00	0.	6190.	29206.	269.37
-2.00	0.	1.28E+00	0.	5817.	35216.	288.99
-3.00	0.	1.45E+00	0.	5362.	40813.	308.61
-4.00	0.	1.61E+00	0.	4825.	45913.	328.23
-5.00	0.	1.75E+00	0.	4237.	50446.	347.86
-6.00	0.	1.88E+00	0.	3629.	54380.	367.48
-7.00	0.	1.99E+00	0.	3002.	57698.	387.10
-8.00	0.	2.09E+00	0.	2355.	60378.	406.73
-9.00	0.	2.18E+00	0.	1689.	62401.	426.35
-10.00	0.	2.24E+00	0.	1002.	63748.	445.97
-11.00	0.	2.29E+00	0.	297.	64400.	465.59
-12.00	0.	2.32E+00	0.	-429.	64335.	485.22
-13.00	0.	2.34E+00	0.	-1174.	63535.	504.84
-14.00	0.	2.34E+00	0.	-1938.	61981.	524.46
-15.00	0.	2.32E+00	0.	-2723.	59652.	544.08
-16.00	0.	2.28E+00	0.	-3527.	56529.	563.71
-17.00	0.	2.23E+00	0.	-4350.	52592.	583.33
-18.00	0.	2.16E+00	0.	-5193.	47822.	602.95
-19.00	0.	2.09E+00	0.	-6056.	42199.	622.58
-20.00	0.	2.00E+00	0.	-6938.	35703.	642.20
-21.00	0.	1.90E+00	0.	-7840.	28316.	661.82
-22.00	0.	1.79E+00	0.	-8762.	20016.	681.44
-22.00	0.	1.79E+00	0.	-8762.	20016.	-2493.38
-23.00	0.	1.68E+00	0.	-6591.	12352.	-2342.29
-24.00	0.	1.56E+00	0.	-4623.	6770.	-2060.83
-25.00	0.	1.45E+00	0.	-2975.	2999.	-1733.94
-26.00	0.	1.33E+00	0.	-1656.	711.	-1404.70
-27.00	0.	1.21E+00	0.	-666.	-423.	-1074.85
-28.00	0.	1.09E+00	0.	-6.	-731.	-745.27
-29.00	0.	9.73E-01	0.	325.	-544.	-416.20
-30.00	0.	8.55E-01	0.	327.	-191.	-87.54
-31.00	0.	7.37E-01	0.	0.	0.	240.97

elevation +4 (page 34). It should also be noted that the wall above the anchor displaces into the backfill, causing soil pressures in this area to tend toward the passive state. This characteristic is ignored in the classical design procedure, which assumes ultimate active pressure to exist in this region.

Example 3--Multiple-Anchored Retaining Wall

41. The wall-soil system is shown in Figure 9, and system properties are given in Table 2. No classical design procedure exists for this system. In the analysis for this wall, the concrete slab on the leftside surface was treated as a pair of tension-only anchors (i.e., if the wall moves to the left [positive], the slab produces a reaction toward the right). The input file appears as follows:

```
1000  MULTIPLE ANCHORED WALL
1005  DRIVEN IN SAND WITH SAND BACKFILL
1007  CONCRETE SLAB TREATED AS TWO TENSION ONLY ANCHORS
1010  WALL        34.50     -26.00    29.0E+06    220.40      9.40
1020  ANCHORS
1030   14.50  T      2.90E+07    5.00E+04      1.096   69.00       0.00
1040   -2.00  T      2.90E+07    5.00E+04      1.474    44.00       0.00
1050  -14.00  T      3.00E+06    3.00E+03    216.00      6.00       0.00
1060  -15.00  T      3.00E+06    3.00E+03    216.00      6.00       0.00
1070  RIGHTSIDE
1080       34.50   110.00     34.00      0.00      0.00       .40      2.90     20.00
1090       14.50   110.00     34.00      0.00      0.00       .40      2.90     16.50
1100        5.50   128.50     34.00      0.00      0.00       .40      2.00     16.50
1110       -2.00   132.00     33.00      0.00      0.00       .50      2.90     12.50
1120  LEFTSIDE
1130      -16.00   132.00     33.00      0.00      0.00       .50      2.90     10.00
1140  WATER      62.50      5.500      -2.00
1150  SURCHARGE       0.00     450.00
1160  FINISHED
```

Figure 10 shows plots of the results. The echoprint of input data is shown on page 41.

42. Output from CSHTSSI is given on pages 42-44. The zero force in the anchor representing the upper part of the concrete slab (summary of results, page 43) indicates the wall is not in contact with the slab at this point (see results at elevation -15, page 44).

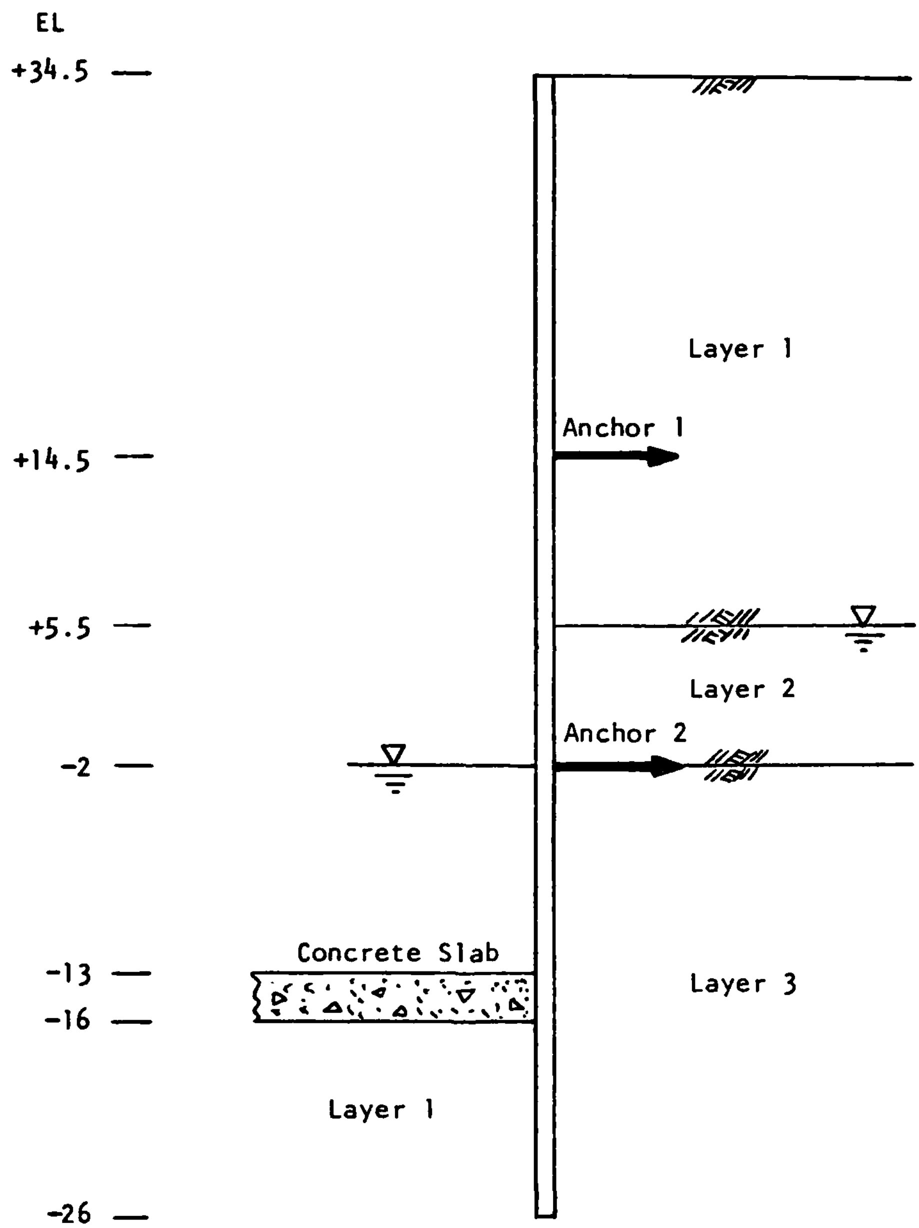


Figure 9. Wall-soil system for example 3

Table 2

System Properties for Example 3

Wall:	$E = 29 \times 10^6$ psi $I = 220.4$ in.^{4} $A = 9.4$ in.^{2}
Anchor 1:	$E = 29 \times 10^6$ psi $A = 1.096$ in.^{2} (3-1/8-in. diam at 7-ft spacing) $L = 26$ ft $f_y = 50$ ksi
Anchor 2:	$E = 29 \times 10^6$ psi $A = 1.474$ in.^{2} (3-5/8-in. diam at 7-ft spacing) $L = 44$ ft
Slab:	$E = 3 \times 10^6$ psi $f_y = 3000$ psi
Rightside soil (all sand):	
Layer 1:	$\gamma = 110$ pcf $\phi = 34°$ $K_o = 0.4$ $K_s = 2.9$ pci/ft
Layer 2:	Same as layer 1
Layer 3:	$\gamma = 128.5$ pcf $\phi = 34°$ $K_o = 0.4$ $K_s = 2.0$ pci/ft
Layer 4:	$\gamma = 132$ pcf $\phi = 33°$ $K_o = 0.5$ $K_s = 2.9$ pci/ft
Leftside layer 1:	Same as rightside layer 4
Water:	$\gamma = 62.5$ pcf

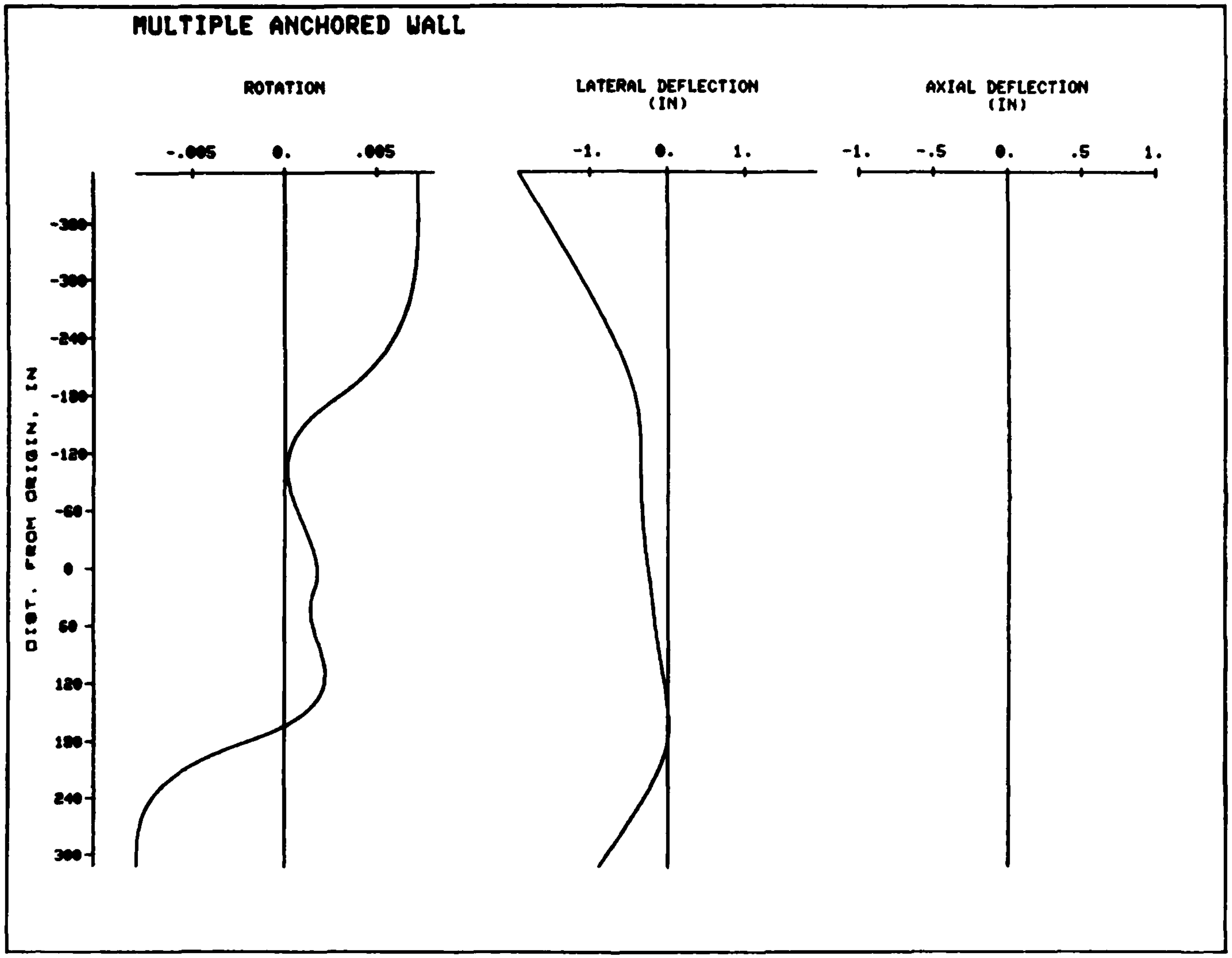


Figure 10. Plots of results for example 3 (Sheet 1 of 3)

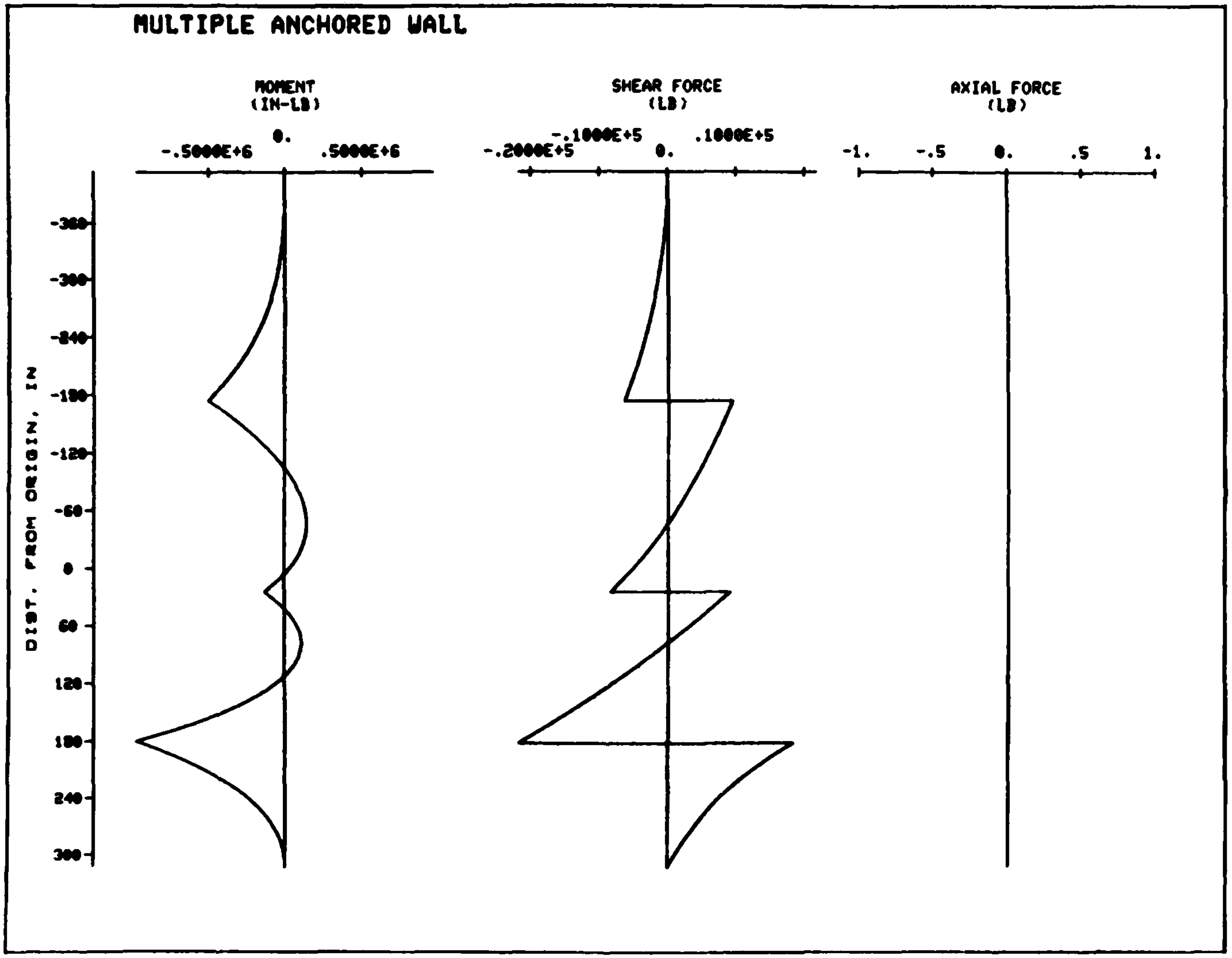


Figure 10. (Sheet 2 of 3)

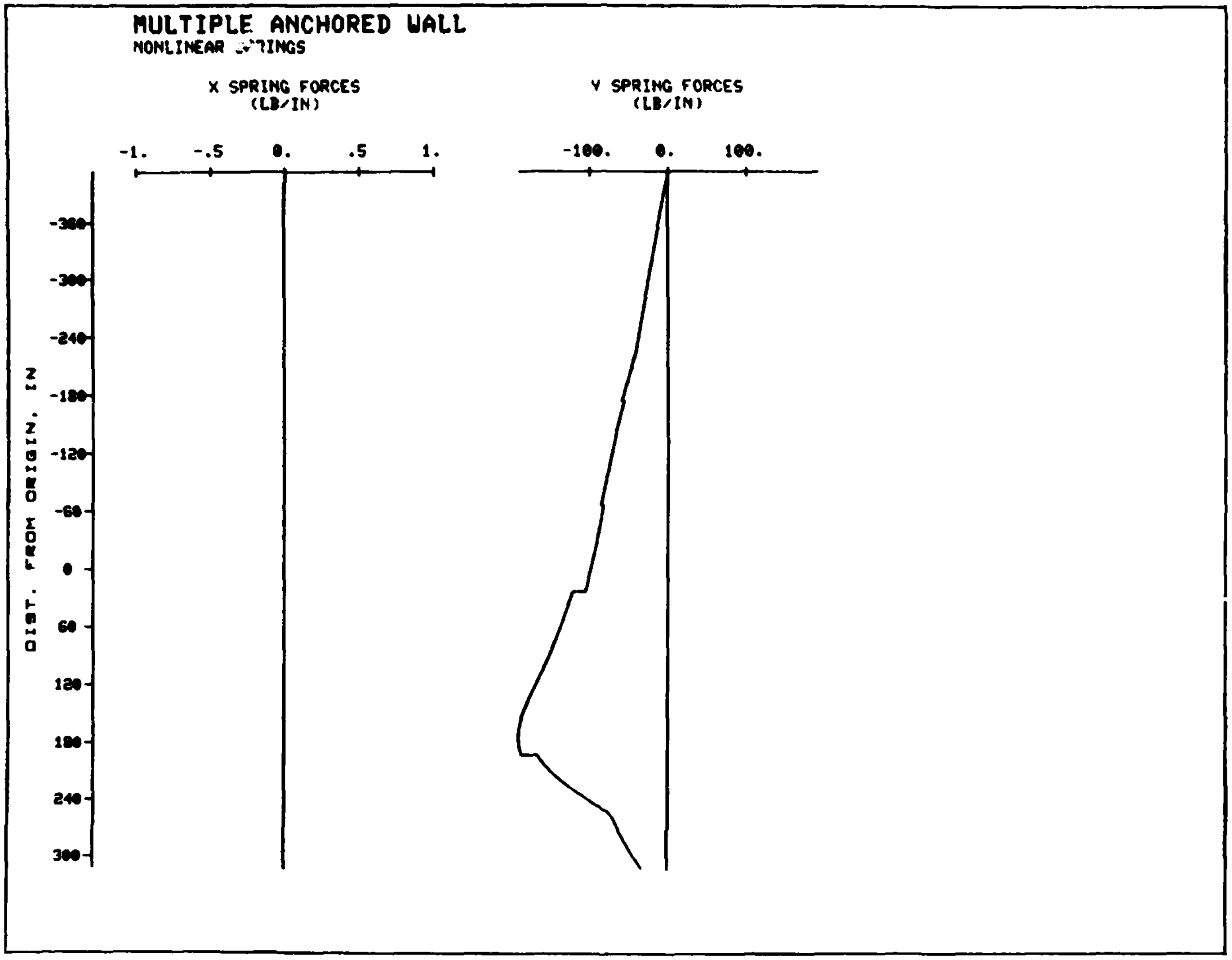


Figure 10. (Sheet 3 of 3)

PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/09/83 TIME: 13:31:21

I.--INPUT DATA

1.--HEADING

MULTIPLE ANCHORED WALL
DRIVEN IN SAND WITH SAND BACKFILL
CONCRETE SLAB TREATED AS TWO TENSION ONLY ANCHORS

2.--WALL DATA

ELEVATION AT TOP OF WALL	=	34.50	(FT)
ELEVATION AT BOTTOM OF WALL	=	-26.00	(FT)
WALL MODULUS OF ELASTICITY	=	29.0E+06	(PSI)
WALL MOMENT OF INERTIA	=	220.40	(IN**4)
WALL CROSS SECTION AREA	=	9.40	(SQIN)

3.--ANCHOR DATA

ANCH NO	ELEV AT WALL (FT)	TYPE	MODULUS OF ELAST (PSI)	YIELD STRESS (PSI)	CROSS SECTION AREA (SQIN)	EFFECT LENGTH (FT)	SLOPE (FT/FT)
1	14.50	T	29.E+06	50000.	1.10	69.00	1: 0.00
2	-2.00	T	29.E+06	50000.	1.47	44.00	1: 0.00
3	-14.00	T	30.E+05	3000.	216.00	6.00	1: 0.00
4	-15.00	T	30.E+05	3000.	216.00	6.00	1: 0.00

4.--RIGHTSIDE SOIL DATA

LAYER NO	TOP ELEV AT WALL (FT)	UNIT WEIGHT (PCF)	INTERN FRICT (DEG)	COH-HESION (PSF)	WALL FRICT (DEG)	AT-REST COEFF	SOIL MODULUS (PCI)	INTERACT DISTANCE (FT)
1	34.50	110.00	34.00	0.00	0.00	.40	2.90	20.00
2	14.50	110.00	34.00	0.00	0.00	.40	2.90	16.50
3	5.50	128.50	34.00	0.00	0.00	.40	2.00	16.50
4	-2.00	132.00	33.00	0.00	0.00	.50	2.90	12.50

5.--LEFTSIDE SOIL DATA

LAYER NO	TOP ELEV AT WALL (FT)	UNIT WEIGHT (PCF)	INTERN FRICT (DEG)	COH-HESION (PSF)	WALL FRICT (DEG)	AT-REST COEFF	SOIL MODULUS (PCI)	INTERACT DISTANCE (FT)
1	-16.00	132.00	33.00	0.00	0.00	.50	2.90	10.00

6.--WATER DATA

WATER UNIT WEIGHT	=	62.50	(PCF)
RIGHTSIDE WATER ELEVATION	=	5.50	(FT)
LEFTSIDE WATER ELEVATION	=	-2.00	(FT)

7.--SURFACE SURCHARGE LOADS

RIGHTSIDE SURCHARGE	=	0.00	(PSF)
LEFTSIDE SURCHARGE	=	450.00	(PSF)

8.--HORIZONTAL LINE LOADS
NONE

9.--HORIZONTAL APPLIED PRESSURES
NONE

```
PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/09/83                          TIME: 13:31:34

II.--NONLINEAR CURVE DATA GENERATED BY CSHTSSI

II.A.--HEADING
  MULTIPLE ANCHORED WALL
  DRIVEN IN SAND WITH SAND BACKFILL
  CONCRETE SLAB TREATED AS TWO TENSION ONLY ANCHORS


II.B.--ANCHOR NONLINEAR SPRING DATA

     ANCHOR ELEV.      14.50 (FT)        TENSION      COMPRESSION
                                          YIELD          YIELD
               DEFORMATION (FT):  1.1897E-01      0.
               FORCE (LB)      :  5.4800E+04      0.

     ANCHOR ELEV.      -2.00 (FT)        TENSION      COMPRESSION
                                          YIELD          YIELD
               DEFORMATION (FT):  7.5862E-02      0.
               FORCE (LB)      :  7.3700E+04      0.

     ANCHOR ELEV.     -14.00 (FT)        TENSION      COMPRESSION
                                          YIELD          YIELD
               DEFORMATION (FT):  6.0000E-03      0.
               FORCE (LB)      :  6.4800E+05      0.

     ANCHOR ELEV.     -15.00 (FT)        TENSION      COMPRESSION
                                          YIELD          YIELD
               DEFORMATION (FT):  6.0000E-03      0.
               FORCE (LB)      :  6.4800E+05      0.


II.C.--RIGHTSIDE SOIL NONLINEAR SPRING DATA


     ELEVATION      34.50 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  1.0000E+03  0.             -1.0000E+03
               PRESSURE (PSF)   :        0.00         0.00         0.00


     ELEVATION      14.50 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  5.1490E-02  0.             -1.3773E+00
               PRESSURE (PSF)   :      621.97       880.00      7781.69


     ELEVATION      14.50 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  4.2479E-02  0.             -1.1362E+00
               PRESSURE (PSF)   :      621.97       880.00      7781.69


     ELEVATION       5.50 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  4.2479E-02  0.             -1.1362E+00
               PRESSURE (PSF)   :      901.86      1276.00     11283.45


     ELEVATION       5.50 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  3.6957E-02  0.             -9.8852E-01
               PRESSURE (PSF)   :      901.86      1276.00     11283.45


     ELEVATION      -2.00 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  3.6957E-02  0.             -9.8852E-01
               PRESSURE (PSF)   :     1041.80      1474.00     13034.33


     ELEVATION      -2.00 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  3.5574E-02  0.             -5.0138E-01
               PRESSURE (PSF)   :     1086.34      1842.50     12499.96


     ELEVATION     -26.00 (FT)          ACTIVE       AT-REST      PASSIVE
               DISPLACEMENT (FT):  3.5574E-02  0.             -5.0138E-01
               PRESSURE (PSF)   :     1578.07      2676.50     18158.02
```

II.D.--LEFTSIDE SOIL NONLINEAR SPRING DATA

ELEVATION -16.00 (FT)	PASSIVE	AT-REST	ACTIVE
DISPLACEMENT (FT):	4.0111E-01	0.	-2.84[illegible]E-02
PRESSURE (PSF) :	-1526.45	-225.00	-132.66

ELEVATION -26.00 (FT)	PASSIVE	AT-REST	ACTIVE
DISPLACEMENT (FT):	4.0111E-01	0.	-2.[illegible]45[illegible]E-02
PRESSURE (PSF) :	-3883.9[illegible]	-572.50	-337.55

PROGRAM CSHTSSI - SOIL-STRUCTURE INTERACTION ANALYSIS
OF CANTILEVER OR ANCHORED SHEET PILE RETAINING WALLS
DATE: 02/09/83 TIME: 13:31:55

III.--SUMMARY OF RESULTS

III.A.--HEADING
MULTIPLE ANCHORED WALL
DRIVEN IN SAND WITH SAND BACKFILL
CONCRETE SLAB TREATED AS TWO TENSION ONLY ANCHORS

III.B.--MAXIMA

	MAXIMUM POSITIVE	ELEV (FT)	MAXIMUM NEGATIVE	ELEV (FT)
AXIAL DISPLACEMENT (IN) :	0.	0.00	0.	0.00
LATERAL DISPLACEMENT (IN):	1.92E+00	34.50	-1.24E-02	-13.50
AXIAL FORCE (LB) :	0.	0.00	0.	0.00
SHEAR (LB) :	1.84E+04	-15.00	-2.18E+04	-15.00
BENDING MOMENT (LB-FT) :	1.19E+04	4.00	-8.09E+04	-15.00

III.C.--ANCHOR FORCES

ANCHOR ELEV (FT)	ANCHOR FORCE (LB)
14.50	15802.
-2.00	17484.
-14.00	0.
-15.00	40172.

IV.--COMPLETE RESULTS

IV.A.--HEADING
MULTIPLE ANCHORED WALL
DRIVEN IN SAND WITH SAND BACKFILL
CONCRETE SLAB TREATED AS TWO TENSION ONLY ANCHORS

IV.B.--COMPLETE RESULTS

ELEV (FT)	<----DEFLECTIONS---> AXIAL (IN)	LATERAL (IN)	AXIAL FORCE (LB)	SHEAR (LB)	BENDING MOMENT (LB-FT)	SOIL PRESSURE (PSF)
34.50	0.	1.92E+00	0.	0.	0.	0.00
33.50	0.	1.84E+00	0.	-16.	-5.	31.10
32.50	0.	1.75E+00	0.	-62.	-41.	62.20
31.50	0.	1.66E+00	0.	-140.	-140.	93.30
30.50	0.	1.58E+00	0.	-249.	-332.	124.39
29.50	0.	1.49E+00	0.	-389.	-648.	155.49
28.50	0.	1.40E+00	0.	-560.	-1120.	186.59
27.50	0.	1.32E+00	0.	-762.	-1778.	217.69
26.50	0.	1.23E+00	0.	-995.	-2654.	248.79
25.50	0.	1.15E+00	0.	-1259.	-3778.	279.89
24.50	0.	1.06E+00	0.	-1555.	-5183.	310.99
23.50	0.	9.80E-01	0.	-1881.	-6899.	342.09
22.50	0.	8.99E-01	0.	-2239.	-8956.	373.18
21.50	0.	8.21E-01	0.	-2628.	-11387.	404.28
20.50	0.	7.46E-01	0.	-3048.	-14222.	435.38
19.50	0.	6.75E-01	0.	-3499.	-17493.	466.48
18.50	0.	6.08E-01	0.	-3981.	-21230.	500.85
17.50	0.	5.47E-01	0.	-4508.	-25470.	553.73
16.50	0.	4.93E-01	0.	-5088.	-30263.	606.56
15.50	0.	4.48E-01	0.	-5721.	-35663.	658.39
14.50	0.	4.12E-01	0.	-6404.	-41721.	708.09
14.50	0.	4.12E-01	0.	9398.	-41721.	671.62
13.50	0.	3.86E-01	0.	8703.	-32667.	718.74
12.50	0.	3.70E-01	0.	7962.	-24331.	762.21
11.50	0.	3.60E-01	0.	7179.	-16757.	802.69
10.50	0.	3.54E-01	0.	6357.	-9985.	840.91
9.50	0.	3.51E-01	0.	5498.	-4055.	877.69
8.50	0.	3.50E-01	0.	4602.	998.	913.87
7.50	0.	3.48E-01	0.	3670.	5137.	950.31
6.50	0.	3.45E-01	0.	2701.	8326.	987.81
5.50	0.	3.39E-01	0.	1694.	10527.	1027.11
5.50	0.	3.39E-01	0.	1694.	10527.	989.92
4.50	0.	3.31E-01	0.	659.	11711.	1017.55
3.50	0.	3.19E-01	0.	-467.	11815.	1048.24
2.50	0.	3.05E-01	0.	-1688.	10745.	1082.16
1.50	0.	2.87E-01	0.	-3008.	8405.	1119.21
.50	0.	2.68E-01	0.	-4428.	4696.	1158.97
-.50	0.	2.47E-01	0.	-5951.	-485.	1200.58
-1.50	0.	2.26E-01	0.	-7579.	-7241.	1242.77
-2.00	0.	2.16E-01	0.	-8432.	-11243.	1263.53
-2.00	0.	2.16E-01	0.	9052.	-11243.	1459.95
-2.50	0.	2.07E-01	0.	8080.	-6959.	1490.03
-3.50	0.	1.90E-01	0.	6092.	131.	1548.97
-4.50	0.	1.73E-01	0.	4044.	5204.	1609.04
-5.50	0.	1.54E-01	0.	1935.	8199.	1672.82
-6.50	0.	1.34E-01	0.	-241.	9052.	1741.99
-7.50	0.	1.11E-01	0.	-2489.	7693.	1817.23
-8.50	0.	8.57E-02	0.	-4815.	4048.	1898.04
-9.50	0.	5.96E-02	0.	-7224.	-1964.	1982.62
-10.50	0.	3.41E-02	0.	-9718.	-10428.	2067.74
-11.50	0.	1.15E-02	0.	-12295.	-21427.	2148.56
-12.50	0.	-5.23E-03	0.	-14949.	-35043.	2218.46
-13.50	0.	-1.24E-02	0.	-17663.	-51345.	2268.94
-14.00	0.	-1.11E-02	0.	-19036.	-60519.	2283.66
-14.00	0.	-1.11E-02	0.	-19036.	-60519.	2283.66
-14.50	0.	-5.71E-03	0.	-20414.	-70382.	2289.37
-15.00	0.	4.46E-03	0.	-21792.	-80934.	2284.41
-15.00	0.	4.46E-03	0.	18379.	-80934.	2284.41
-15.50	0.	1.99E-02	0.	17007.	-72087.	2267.44
-16.00	0.	4.02E-02	0.	15645.	-63925.	2239.03
-16.00	0.	4.02E-02	0.	15645.	-63925.	2003.17
-16.50	0.	6.48E-02	0.	14425.	-56409.	1938.95
-17.50	0.	1.25E-01	0.	12095.	-43163.	1776.16
-18.50	0.	1.97E-01	0.	9948.	-32158.	1572.71
-19.50	0.	2.78E-01	0.	8024.	-23192.	1334.21
-20.50	0.	3.65E-01	0.	6353.	-16026.	1065.61
-21.50	0.	4.56E-01	0.	4955.	-10394.	841.71
-22.50	0.	5.50E-01	0.	3686.	-6080.	757.37
-23.50	0.	6.46E-01	0.	2506.	-2992.	664.18
-24.50	0.	7.43E-01	0.	1423.	-1036.	562.46
-25.50	0.	8.40E-01	0.	446.	-110.	452.47
-26.00	0.	8.88E-01	0.	0.	0.	394.42

APPENDIX A: GUIDE FOR DATA INPUT

Source of Input

1. Input data must be supplied from a predefined data file or from the user terminal during execution. If data are supplied from the user terminal, prompting messages are printed to indicate the amount and character of data to be entered.

Data Editing

2. When all data for a problem have been entered, the user is offered the opportunity to review an echoprint of the currently available input data and to revise any or all sections of the input data before execution is attempted. When editing during execution, the user must enter each section in its entirety.

Input Data File Generation

3. After data have been entered from the terminal, either initially or after editing, the user may direct the program to write the input data to a permanent file in input data file format.

Data Format

4. All input data (whether supplied from the user terminal or from a file) are read in free-field format; i.e.:

- a. Data items must be separated by one or more blanks (comma separators are not permitted).
- b. Integer number must be of the form NNNN.
- c. Real numbers must be of the form

  ±xxxx, ±xx.xx, or ±xx.xxE±ee
- d. User responses to all requests for control by the program for alphanumeric input may be abbreviated by the first letter of the indicated word response; e.g.,

ENTER 'YES' OR 'NO'--respond Y or N
ENTER 'CONTINUE' OR 'END'--respond C or E

Carriage return responses alone will cause abnormal termination of the program.

Sections of Input

5. Input data are divided into the following sections:

   a. Heading.

   b. Wall Cross-Sectional Properties.

   c. Anchor Data.

   d. Rightside Soil Data.

   e. Leftside Soil Data.

   f. Water Data.

   g. Surface Surcharge Loads.

   h. Horizontal Line Loads.

   i. Horizontal Applied Pressures.

6. Input data sections a, b, d, and e above are required; other sections may be omitted.

Predefined Data File

7. In addition to the general format requirements given in paragraph 4, above, the following pertain to a predefined data file and to the input data description which follows:

   a. Each line must commence with a nonzero, positive line number, denoted LN below.

   b. A line of input may require both alphanumeric and numeric data items. Alphanumeric data items are enclosed in single quotes in the following paragraphs.

   c. A line of input may require a keyword. The acceptable abbreviation for the keyword is indicated by underlined capital letters; e.g., the acceptable abbreviation for the keyword 'WATer' is 'WAT'.

   d. Lowercase words in single quotes indicate a choice defined following.

e. Items designated by uppercase letters and numbers without quotes indicate numeric data values. Numeric data values are either real or integer according to standard FORTRAN variable naming conventions.

f. Data items enclosed in brackets [ ] may not be required. Data items enclosed in braces { } indicate a special note follows.

g. Input data are divided into the sections discussed in paragraph 5 above. Except for the heading, each section consists of a header line and one or more data lines. The header line serves the dual purposes of: indicating the end of the preceding section; identifying the data section to follow.

h. Comment lines may be inserted in the input file by enclosing the line, following the line number, in parentheses. Comment lines are ignored; e.g.,

1234ƀ(THIS LINE IS IGNORED)

Input Description

8. Heading--One (1) to four (4) lines for identifying the problem:

a. Line contents

LN 'Heading'

b. Definitions

LN = nonzero integer line number

'heading' = any alphanumeric information up to 70 characters including LN and any embedded blanks

c. Restriction: If a 'heading' line following LN begins with a letter which is the first letter of any of the keywords described below, the 'heading' must begin with a single quote.

9. Wall Data--One (1) line:

a. Contents

LN 'WAL1' TOPEL BOTEL WALLE WALLI WALLA

b. Definitions

'WAL1' = section title

TOPEL = elevation (ft) at top of wall

BOTEL = elevation (ft) at bottom of wall

WALLE = wall modulus of elasticity (psi)

WALLI = wall moment of inertia ($in.^4$)

WALLA = wall cross-sectional area (sq in.)

10. Anchor Data--Zero (0) to five (5) lines. Omit entire section if no anchors are present:

a. Header--One (1) line

a(1) Contents

LN 'Anchor'

a(2) Definition

'Anchor' = section title

b. Anchor Data Lines--One (1) to four (4) lines. One line for each anchor

b(1) Contents

LN ANCHEL 'type' [ANCHE ANCHFY ANCHA ANCHL ANCSLO]

b(2) Definitions

ANCHEL = elevation (ft) of anchor attachment at wall

'type' = 'T' for tension-only anchor

= 'R' for rigid anchor

= 'C' for compression-only anchor

= 'TC' for tension-or-compression anchor

ANCHE* = anchor modulus of elasticity (psi)

ANCHY* = anchor yield stress (psi)

ANCHA* = anchor cross-sectional area (sq in.)

ANCHL* = anchor effective length (ft)

ANCLSO* = anchor slope (ft); positive if anchor slopes downward away from wall

c. Discussion

c(1) Anchors may be at any elevation between the top and bottom of the wall.

c(2) Anchors may be described in any order.

c(3) Anchors are assumed to extend to the right away from the wall.

c(4) Rigid anchors are assumed to prevent all horizontal motion of the point of attachment. Items denoted by an asterisk in paragraph b(2) above are not required for rigid anchors.

c(5) Non-rigid anchors are treated as elasto-plastic nonlinear springs.

c(6) Anchor slope is interpreted as feet of drop (positive) or rise (negative) per foot or horizontal distance from wall.

11. Rightside Soil Data--Two (2) to sixteen (16) lines:

a. Header--One (1) line

a(1) Contents

LN 'Rightside'

a(2) Definition

'Rightside' = section title

b. Soil Layer Data Lines--One (1) to fifteen (15) lines. One line for each layer

b(1) Contents

LN ELLAYR GAMRT PHIRT CRT DELTRT RSTKRT ESRT DRT

b(2) Definitions

ELLAYR = elevation (ft) of top of layer at wall

GAMRT = saturated unit weight (pcf)

PHIRT = angle of internal friction (deg)

CRT = cohesion (psf)

DELTRT = angle of wall friction (deg)

RSTKRT = at-rest earth pressure coefficient

ESRT = modulus of elasticity (pci/ft) for cohesive soil

= soil modulus coefficient (pci/ft) for cohesionless soil

DRT = interaction distance (ft)

c. Discussion

c(1) Soil layer data must begin with the topmost layer and proceed sequentially downward.

c(2) The last soil layer provided is assumed to extend ad infinitum downward.

c(3) The effective unit weight of soil is calculated by the program by subtracting the weight of water (if present) from the saturated unit weight for submerged soil.

c(4) Either PHIRT or CRT, but not both, may be zero.

c(5) Angle of wall friction, DELTRT, is positive if wall friction tends to reduce active soil pressure.

c(6) At-rest pressure coefficient, RSTKRT, must be positive, greater than zero, and less than one.

c(7) Soil modulus, ESRT, is assumed to be constant within the layer if CRT is greater than zero.

c(8) For cohesionless soils (CRT = 0); effective soil modulus is assumed to vary linearly with depth and is calculated by the program from

$$E_S = ESRT \cdot \sigma_v / \gamma_e$$

where

E_S = effective soil modulus

ESRT = input soil modulus

σ_v = vertical pressure

γ_e = effective soil unit weight: GAMRT or (GAMRT-GAMWAT)

c(9) DRT must be greater than zero.

12. Leftside Soil Data--Two (2) to sixteen (16) lines:

a. Header--One (1) line

a(1) Contents

LN 'LEFtside'

b(2) Definition

'LEFtside = section title

b. Soil Layer Data Lines--One (1) to Fifteen (15) lines. One line for each layer

b(1) Contents

LN ELLAYL GAMLT PHILT CLT DELTLT RSTKLT ESLT DLT

b(2) Definitions

ELLAYL = elevation (ft) of top of layer at wall

GAMLT = saturated unit weight (pcf)

PHILT = angle of internal friction (deg)

CLT = cohesion (psf)

DELTLT = angle of wall friction (deg)

RSTKLT = at-rest earth pressure coefficient

ESLT = modulus of elasticity (psi/ft) for cohesive soil

= soil subgrade modulus (psi/ft) for cohesionless soil

DLT = interaction distance (ft)

c. Discussion

c(1) Soil layer data must begin with the topmost layer and proceed sequentially downward.

c(2) The last soil layer provided is assumed to extend ad infinitum downward.

c(3) The effective unit weight of soil is calculated by the program by subtracting the weight of water (if present) from the saturated unit weight for submerged soil.

c(4) Either PHILT or CLT, but not both, may be zero.

c(5) Angle of wall friction, DELTLT, is positive if wall friction tends to reduce active soil pressure.

c(6) At-rest pressure coefficient, RSTKLT, must be positive, greater than zero and less than one.

c(7) Soil modulus, ESLT, is assumed to be constant within the layer if CLT is greater than zero.

c(8) For cohesionless soils (CLT = 0), effective soil modulus is assumed to vary linearly with depth and is calculated by the program from

$$E_S = ESLT \cdot \sigma_v / \gamma_e$$

where

E_S = effective soil modulus

ESLT = input soil modulus

σ_v = vertical pressure

γ_e = effective soil unit weight; GAMLT or GAMLT-GAMWAT)

c(9) DLT must be greater than zero.

13. Water Data--Zero (0) or One (1) line. Omit entire section if water is not present:

a. Contents

[LN 'WATer' GAMWAT WATELR WATELL]

b. Definitions

'WATer' = section title

GAMWAT = water unit weight (pcf)

WATELR = Water level elevation (ft) on right side of wall

WATELL = water level elevation (ft) on left side of wall

14. Surface Surcharge Loads--Zero (0) or One (1) line. Omit entire section if no surcharge loads:

a. Contents

[LN 'Surcharge' SURCHR SURCHL]

b. Definitions

'Surcharge' = section title

SURCHR = magnitude of uniform surcharge (psf) on rightside surface

SURCHL = magnitude of uniform surcharge (psf) on leftside surface

15. Horizontal Line Loads--Zero (0) or One (1) line. Omit entire section if no line loads are present:

a. Contents

[LN 'LINe' HOREL(1) PHOR(1) . . .HOREL(4) PHOR(4)]

b. Definitions

'LINe' = section title

HOREL(I) = elevation (ft) of Ith line load

PHOR(I) = magnitude (plf) of Ith line load

c. Discussion

c(1) One (1) to four (4) line loads are permitted.

c(2) Each line load is described by a pair of data values: HOREL and PHOR.

c(3) Line loads acting to the left are positive.

16. Horizontal Applied Pressures--Zero (0) to two (2) lines. Omit entire section if no applied pressures are present:

a. Contents

a(1) First line

[LN 'Pressure' ELPR(1) HORPR(1) . . . ELPR(4) HORPR(4)]

a(2) Second line (may not be required)

[LN ELPR(5) HORPR(5) . . . ELPR(8) HORPR(8)]

b. Definitions

'Pressure' = section title

ELPR(I) = elevation (ft) of Ith pressure point

HORPR(I) = pressure magnitude (psf) at Ith pressure point

c. Discussion

c(1) The applied pressure distribution is described by two (2) to eight (8) pairs of data values: ELPR and HORPR.

c(2) Elevations of pressure points must proceed sequentially from top to bottom.

c(3) Only a single pressure magnitude is permitted at any elevation.

c(4) Pressure is assumed to vary linearly between consecutive points.

c(5) Pressures acting to the left are positive.

Abbreviated Input Guide

17. Data items enclosed in brackets [ ] may be omitted. Data items enclosed in { } indicate choose one. Items enclosed in single quotes indicate alphanumeric data.

18. Heading--One (1) to four (4) lines:

LN 'heading'

[LN 'heading']

[LN 'heading']

[LN 'heading']

19. Wall Data--One (1) line:

LN 'WAL1' TOPEL BOTEL WALLE WALLI WALLA

20. Anchor Data--Zero (0) to five (5) lines. Omit entire section if no anchors:

a. Header--One (1) line

[LN 'Anchors']

b. Data Lines--One (1) to four (4) lines. One line for each anchor

[LN ANCHEL $\left\{\begin{array}{c}\text{'T'}\\ \text{'R'}\\ \text{'C'}\\ \text{'TC'}\end{array}\right\}$ [ANCHE ANCHFY ANCHA ANCHL ANCSLO]

21. Rightside Soil Data--Two (2) to sixteen (16) lines:

a. Header--One (1) line

LN 'Rightside'

b. Data Lines--One (1) to fifteen (15) lines. One line for each soil layer

LN ELLAYR GAMRT PHIRT CRT DELTRT RSTKRT ESRT DRT

22. Leftside Soil Data--Two (2) to sixteen (16) lines:

a. Header--One (1) line

LN 'LEFtside'

b. Data Lines--One (1) to fifteen (15) lines. One line for each soil layer

LN ELLAYL GAMLT PHILT CLT DELTLT RSTKLT ESLT DLT

23. Water Data--Zero (0) or one (1) line:

[LN 'WATer' GAMWAT WATELR WATELL]

24. Surface Surcharge Loads--Zero (0) or one (1) line:

[LN 'Surcharge' SURCHR SURCHL]

25. Horizontal Line Loads--Zero (0) or one (1) line:

[LN 'LINe' HOREL PHOR HOREL PHOR HOREL PHOR HOREL PHOR]

26. Horizontal Applied Pressures--Zero (0) to two (2) lines:

[LN 'Pressure' ELPR HORPR ELPR HORPR ELPR HORPR ELPR HORPR]

[LN ELPR HORPR ELPR HORPR ELPR HORPR ELPR HORPR]

END

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